Vol. XXIX, No. 4 *Whole No. 249*

APRIL, 1929

SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

A Journal for all SCIENCE AND MATHEMATICS TEACHERS

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Published by THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS
Publication Office: 404 N. WESLEY AVE., MOUNT MORRIS, ILLINOIS
Business Office: 1439 FOURTEENTH ST., MILWAUKEE, WISCONSIN
Editorial Office: 7633 CALUMET AVE., CHICAGO, ILLINOIS

Published monthly, October to June, Inclusive, at Mount Morris, Illinois *Price, $2.50 Per Year: 35 Cents Per Copy*
Entered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois, under the Act of March 3, 1879

SCHOOL SCIENCE AND MATHEMATICS

VOL. XXIX No. 4 APRIL, 1929 WHOLE No. 249

EDITORIAL COMMENT AND NEWS

SCHOOL SCIENCE AND MATHEMATICS is a journal devoted to the teaching of all branches of science and mathematics. It is distinctly a journal for classroom teachers—owned by teachers, managed by teachers, edited by teachers. In selecting material for publication the chief criterion is its value to the classroom teacher.

Our purpose is coordination. The elementary or secondary school teacher should not be a highly trained specialist in only one particular branch of learning. His education should be broad and his interests varied. He needs to know the relation of the work of his particular subject and level to that of the same subject at levels above and below, in order that he may properly contribute to building a consecutive dependent course. He must know how his subject contributes to the work of other related subjects and how it is dependent upon other departments for its development. In this connection mathematics must be considered not apart from the other sciences but as the most fundamental of all the sciences.

In the past children have been taught to read and enjoy literature and history in the primary grades but the introduction to the great field of science (except mathematics) was left for the high school level. Some years ago a few leaders caught a glimpse of this neglected opportunity and elementary science was introduced in favored localities. The movement has spread rapidly but there has grown up a series of largely unrelated science topics which constitute the elementary science work, where it is given, and the secondary school still continues its science instruction in specialized independent branches. Such independent activity is wasteful and frequently futile. A complete reorgan-

ization of all science instruction into a consecutive dependent course through the twelve school years is needed. To promote this reorganization is our aim.

We are pleased to announce some additions to our editorial staff.

The Zoology Department is now in charge of Mr. Joel Hadley of Shortridge High School, Indianapolis. Mr. Hadley is recognized as one of the leaders in this branch of science instruction. He is especially interested in field work, with bird study as his hobby.

Miss Katherine Ulrich of the Oak Park-River Forest Township High School is now promoting the work in Geography. She has been intimately connected with the Central Association of Science and Mathematics Teachers for several years, knows both subject matter and the teaching phases of geography and has a clear record of success in all enterprises.

A new department has been created to encourage the development of elementary science. Mr. Harry A. Carpenter of West High School, Rochester, N. Y., and Specialist in Science for the Junior and Senior High Schools of Rochester is head of this department. Mr. Carpenter is known all over the country for his recent contributions in this field.

TEACHERS INTERESTED IN GENERAL SCIENCE

The editors of School Science and Mathematics are anxious to have the magazine be helpful to teachers. Will you please let us know what your most difficult problems are? Attempts will be made to have many of our best known science teachers give solutions to those problems. We hope this will lead to a healthy discussion of many of the perplexing problems science teachers are compelled to face.

Many teachers have developed special techniques for teaching certain topics or units. Other teachers would be benefited by reading about them. Brief descriptions of these methods would be appreciated by teachers.

The results of investigations and research are of value to teachers only if they are published. School Science and Mathematics will be glad to publish the findings.

Communications of interest to general science teachers will be appreciated. Please let us hear from you.

Ira C. Davis,
General Science Editor.

SOME RECENT TENDENCIES IN TEACHING PROCEDURES FOR GENERAL SCIENCE.

By Ralph K. Watkins,

School of Education, University of Missouri, Columbia, Mo.

As a background to observed changes in class procedures in general science it is well to review a few of the things which have been happening to schools. These changes are affecting very materially current practice, although they may be classified as administrative rather than instructural matters.

There is a widespread movement toward single period science schedules. This is especially true of those schools definitely organized as junior high schools. Some four year high schools and some senior high schools are also going on the single period schedule. In Kansas City most science classes in both junior and senior high schools are run on this schedule. General science as a junior high school subject is going rapidly over to the single period basis. The length of the period varies from the regulation 40 or 45 minutes to 50, 55 and 60 minutes. This means considerable reduction in laboratory for those schools attempting to operate on 40 minutes daily. More modern or more radical schools have the longer periods. These schools are able to attempt more laboratory work.

General science classes are getting large. Classes of 30 to 40 are not uncommon. In city schools they may be the rule rather than the exception. Even in village schools where general science is required of ninth graders, sections are large. The old rule of 18, 20 or 24 for science classes has gone by the board. Teaching methods for general science must be adapted to large classes in 1928 and 29.

There is a tendency to introduce general science into all grades of the junior high school. The course is not always called general science. Sometimes it is elementary science, sometimes general science and now and then just science. The intermediate schools of St. Louis have had an elementary science course in all grades of the junior high school for several years. Scattered schools offer the usual general science course in the eighth grade. At least one book company is publishing a general science series with graduated texts for all three years.

There is some tendency to push general science down into the grades. There are courses and texts with general science content for fifth and six grades. Some junior high schools offer general science in grades seven and eight and biology in the ninth

grade. This is not new. The Bureau of Education bulletin on the "Reorganization of Science for Secondary Schools" published in 1920 recommended this.

A rather large number of schools put general science on a two or three hour a week schedule. Industrial arts for boys and home economics for girls are often the alternating courses. In some Oklahoma junior high schools these are called finding courses.

The North Central Association and some state departments and University accrediting agencies have put college entrance upon the basis of the twelve units of credit earned in senior high school. This automatically removes general science from the list of college entrance credit courses. The immediate effect is to leave the way open to make the course in general science, and the teaching procedures, most effective for reaching desirable aims in terms of life rather than in terms of accrediting agencies.

The effects of these administrative trends may be summed up as follows: General science is spreading through the grades of the junior high school. There is a tendency to merge elementary science and general science. Schedules and present accrediting tend to free the course from hard and fast regulations and make possible very flexible adaptations to the group of pupils in any particular class. Large classes and single period schedules tend to limit the amount of individual laboratory work attempted. These same conditions may mean a slipping back into lesson hearing and memoriter text-recitation devices.

Turning from administrative conditions which may affect teaching procedures to trends in the teaching procedures themselves, the following seem to be the more important tendencies in presentday general science teaching:

1. A reduction in individual laboratory work and a corresponding increase in demonstration and various devices for visual instruction.

2. An increase in the use of moving pictures, slides and still films.

3. An increased flexibility in the type of laboratory work and a corresponding flexibility in the schedule for laboratory work.

4. A reduction in formal note-book work and "writing-up" of experiments, tending toward a complete elimination of the older types of science note-books. This is accompanied by a tendency to use work sheets which cover all types of work to be done.

5. The use of individual and committee reports and pupil demonstrations as a means of providing for individual differences and as a means of fixing pupil responsibility for work done.

6. The formation of science clubs as a part of the function of science departments of high schools.

7. The inclusion of groups of science projects as a part of the regular instructural program of the science class. Point schemes for accrediting and recording credit for such work are in common use.

8. Unit organization instead of daily lesson organization is becoming universal in better schools. Several text-books have recognized this principle and are organized on the unit basis. The unit may be a large topic, a problem, a group of problems, or the application and interpretation of an important principle of science.

9. Programs of discursive reading, done for the values which may be derived from the reading rather than as supplementary to the day's lesson, are becoming integral parts of all well conducted general science courses.

10. Work sheets, direction sheets, unit outlines, and instruction sheets which are mimeographed and put into the hands of pupils at the beginning of lesson units, are increasing in use.

11. Objective tests to be applied to the results of instruction for particular lesson units are developing rapidly. In many cases these tests are applied both as initial and as end tests. In some situations unit tests are applied as preliminary tests and as mastery tests after re-teaching.

Certain theoretical advantages seem inherent in these tendencies. Whether they are actually attained in every case of actual use may remain a question. The procedures described would seem to aid in the fixation of responsibility for the work and consequent learning upon the individual pupils. Individual and committee work and reports, and pupil demonstrations serve this function. Science clubs, projects, reading programs, the use of unit organization and the use of work sheets would all seem to serve the same purpose. Unit tests, especially if administered as initial and final tests, may also help.

The group of modern procedures should have the general effect of varying the work of the general science class furnishing the further possibility of added interest and tending to sustain such interest. Clever and imaginative demonstrations, increased use of pictures and projection equipment, flexibility in

problems attacked in the laboratory, reduction in note-book writing, the science club, discursive reading in magazines and semi-popular books, project work, and varied direction sheets should all help attain this advantage.

The advantage to be found in several of these newer types of instruction would seem to lie in what we have come to recognize as by-product or concomitant learning. That is the values derived from some of these schemes would seem to rest in increased interest in scientific phenomena and applications, change in attitude toward scientific experimentation, increased ability to solve one's own problems, and an increased reading power in the field of scientific literature, rather than in increased direct control of scientific facts and principles. This would seem to be true for committee reports, pupil demonstration, science clubs, science projects and discursive reading, although there is available evidence to show that the direct results of all of these are positive.

All changes and evolutions carry with them, not only possible advantages, but also possible dangers and difficulties. The color of the male cardinal may be an advantage in his spring courting but it also has its disadvantage in the face of a mischievous youngster with a twenty-two rifle or in attempting to escape a prowling cat. So, our trends in science teaching present problems and difficulties.

The details of planning and pupil accounting sometimes become enormous with certain of the newer schemes. Any teacher who has attempted to develop his own unit outlines, work sheets and unit tests is in a position to speak with feeling upon this point. Proper use, selection and evaluation of picture, film and slide material presents the same difficulty on a smaller scale. Mere flexibility of laboratory work means more careful planning. Checking, recording credit, holding pupil conferences, finding material and doing other planning for committee reports, pupil demonstrations, science clubs, reading programs, and projects may be ever so worthwhile but are nevertheless enormously consuming of time and energy.

Certain of our modern tendencies present the danger of slipping into the easiest way out. Single periods, reduced laboratory, increased demonstration, wider use of book materials and printed directions might eventually mean the slipping over into a memoriter scheme of lecturing, notetaking, limited reading, recitation and quizzing. When this happens the

time will be ripe for another instructional revolution.

There is some evidence that modern work sheets and lesson outlines may contain a fairly large amount of mere busy work like the old seat work of the primary schools. Directions which merely keep pupils seemingly busy and quiet may not be educationally worth while. The thing which apparently killed supervised study, as such, may be the ruin of lesson outlines and work sheets.

The advantages of objective tests applied to particular units seem obvious, whether the test be of the commercial type or home-made. We must not ignore the danger, however, that these tests may simply emphasize the memorization of trite and meaningless facts without proper evaluation of worth. There are increasing signs that this danger is near and immediate.

These tendencies, together with their dangers and difficulties, set the stage for some very definite needs in the field of science teaching. Cycles of fads sweeping the country and then dwindling to a residue of practical and useful material should eventually convince teachers that there is no universal panacea in educational methods. The use of problem organization did not cure all the ills of science teaching. Neither did the introduction of laboratory instruction, nor will the elimination of laboratory instruction and the substitution of lecture demonstration. Project teaching has not solved all the problems of science instruction. It is not probable that mimeographed lesson outlines and directions will offer the one and only cure-all. Let us cease the search for blanket methods of instruction.

If we are going to have courses in general science it is high time that we set forth a body of common sense outcomes that may be expected of our pupils. It is exceedingly difficult to construct unit tests in general science because no one seems to be able to predict what the units should be nor what the outcomes of a particular unit should be. The same situation is true of procedures. Should a particular procedure be used because its description looks well on paper and it seems to have certain theoretical advantages or because other teachers seem to have used the method with success? No. A procedure is to be used when a teacher has first determined upon a group of outcomes for his own class and then decides that a type of procedure gives evidence of being useful in producing such outcomes.

Added to such a common sense point of view concerning current methods we need increased activity in attempts to devise

methods which might reasonably aid in producing rather small and specific outcomes. Once such devices are imaginatively produced they need to be clearly and definitely described. The whole field of educational method has been muddled and confused for generations because of the non-existence of any such descriptions. The whole project notion almost died for this reason. Who knows what socialized recitation means, everyone or no one? Science teachers are enormously confused at this minute because the experimenters with educational methods have failed to describe what the methods called individual laboratory instruction and lecture demonstration mean in particular experiments.

With this need for adequate description of useful procedures we need increased inventiveness in the attempt to produce unit tests which may measure other outcomes than mere verbal reproduction of facts and principles. The ultimate evaluation of different types of laboratory instruction awaits the production of such tests.

Finally we need experimenters in the field of educational procedures with the patience to do real scientific experimentation. The essence of proof in cases where there are many variable factors is often much repetition over long periods of time. We have seldom applied this to educational experiments. Some procedures need to be reapplied and remeasured many times with many pupils and teachers and over periods of years rather than weeks. No agriculturalist would have faith in a crop rotation experiment applied in one season. No wonder that science teachers are skeptical of the results of experiments carried through two or three weeks or a few months. May we have a generation of scientific science teachers who will describe procedures for getting at definite outcomes and will then apply such procedures and measure their results over a period of years until some assurance of value or lack of value may be reached.

T. B. TAKES TWO YEARS.

Every white baby boy born in this country could expect to live to 57.3 years if tuberculosis were eradicated, and the country would be saved a loss of $179,000,000. This sum is the annual monetary loss due to deaths from tuberculosis, estimated Harold D. Larsen of the University of Wisconsin.

The loss in life expectation is 1.93 years for every white male at birth.—*Science News-Letter.*

EVOLUTION, HEREDITY AND EUGENICS IN HIGH SCHOOL BIOLOGY.

By Amer M. Ballew,
Austin High School, Chicago, Ill.

The high school curriculum is constantly being revised in an effort to adjust it to the changing conceptions of education. We recognize today that the subject matter taught must have a social significance; that it must relate itself in a very definite way to the problems encountered in the civic life of an individual.

A survey of the biological sciences as they are taught at the present time will show that these aims are not always recognized. We still find a major portion of the time spent in the study of histology and taxonomy. Quite often some of the more social aspects of the subject are practically ignored.

Dr. Counts[1] in his recent survey of the curriculum offerings of fifteen representative cities in the United States, found that evolution, heredity and eugenics received little attention in the average high school biology course. He found an average of 3 per cent of the time was devoted to this topic, and this was chiefly due to the recognition it received in one or two cities. In the courses in botany and zoology it received even less attention. This condition was greatly deplored by Dr. Counts.

It is difficult to justify this situation. Many of our complex social problems can only be solved by the practical application of biological heredity. It is impossible to think of a unit of study that is more intimately related to the social life of an individual. If this be true, why is this division of biology neglected in the schools? There are two answers. First, there are those who do not believe that this subject belongs in the high school biology course. They either believe that the subject is too difficult to present to high school students or that it is a rather delicate one to discuss in mixed classes. The second answer is far more fundamental and serious in its reflection upon society. There is much opposition in many parts of the country to the teaching of the facts and theories concerning evolution. Since heredity and eugenics are intimately related to the study of evolution, they are often omitted. It is a difficult matter to enlighten the public in regard to these subjects without the use of the schools. Some progress may be made by alert teachers in communities where the sentiment is sane in regard to teaching the facts and theories of evolution in its larger applications.

[1]Counts, G. S., The Senior High School Curriculum, University of Chicago Supplementary Educational Monograph, 1926.

The writer has been interested in working out a unit of study in evolution, heredity and eugenics. After several years of trial a unit has been completed for use in the zoology classes of the Austin High School, Chicago. About one month is given over to the study of this unit out of a ten month school year.

The instructor first states the work of the unit in a brief informal talk. The students are then questioned to see how much they may know about the various topics. Sometimes they are encouraged to write out their replies and bring in clippings, pictures, etc., which illustrate some phase of the subject. The student is next given an outline of the work of the unit. Using the outline as a guide the topics are worked out in detail by means of reference books in the room. The instructor supervises the taking of notes and the construction of diagrams as they are made in the classroom. Often the work is halted temporarily so that certain principles may be illustrated by means of a diagram or model.

The student's knowledge is often tested by having him construct an original diagram showing the possible combinations of certain unit characters. Class discussions are held when pronounced difficulties arise in the working out of the unit. When certain major topics are completed the students are asked to discuss these using their condensed outline as a guide. This method is also followed when the entire unit is completed. This makes for unity and a proper understanding of the relative importance of the various topics and their relationships to the aims of the unit.

The condensed outline of the unit is presented as follows:

Unit Aims

1. An intelligent conception of the development of animals from simple to more complex types.
2. Man's place in the universe of living things.
3. Race improvement may be brought about by practical application of biological laws of heredity.

Specific Aims

1. Abundance of proof showing that animals have not always existed in their present forms.
2. Present day scientists believe in evolution but differ in regard to the more probable theory.
3. Man has a definite place in the animal world in past, present, and future animal changes.
4. Definite hereditary laws have been worked out in connection with plant and animal experimentation and by a study of human traits as shown in familial heredity.
5. Characters concerned in heredity are handed down from parent to offspring through structures in germ plasm.
6. Hereditary qualities may be expressed in a diagrammatic way using standard symbols to show possible unit character combinations.

Outline of Unit.

A. Evidences of evolution.
   1. Morphological.
   2. Embryological.
   3. Geological.
   4. Experimental.
   5. Geographical.

B. Theories concerning animal changes.
   1. Darwinian theory.
   2. Lamarckian theory.
   3. Weissmann theory.
   4. De Vries theory.
   5. Orthogenesis.

C. Man's place in evolutionary scheme.
   1. Man's position in relation to other branches of animal life.
   2. Man related to primates but not their direct descendants.
   3. Evidence showing man has undergone changes.
      (a) Morphological.
      (b) Embryological.
      (c) Geological.
   4. Relationship between present day races of people.

D. Mendel's Laws of heredity.
   1. Historical sketch of life and work.
   2. Mating pure bred of same kind.
   3. Mating pure bred of different kinds.
   4. Mating of hybrids.
   5. 3:1 ratio as illustrated by guinea pigs
   6. 1:2:1 ratio as illustrated by guinea pigs.
   7. Dominant and recessive characteristics.
   8. Mutations.

E. How characters are transmitted from parent to offspring.
   1. Structure of typical cell.
   2. Fertilization.
   3. Function of chromosomes.
   4. Function of genes.
   5. Combination of unit characters.

F. Practice in construction and interpretation of heredity diagrams.
   1. Construction of diagram, using standard symbols, tracing human ancestry back three generations.
   2. Construction of diagram tracing coat color of guinea pigs through three generations.
   3. Study of Jonathan Edwards family.
   4. Interpretation of diagrams illustrating Kallikak and Jukes families.
   5. Practice in constructing original diagrams illustrating unit character combinations as following (guinea pig):
      P BB (pure bred black) bb (pure bred white)
      F1 Bb Bb Bb Bb (black hybrids)
      F2 Bb Bb BB bb (1:2:1 ratio)

      (3:1 ratio)

      Note: Different symbols may be used to create a great variety of different possible unit character combinations.
   6. Construction of original diagrams showing possible transmission of undesirable human traits as feeblemindedness and polydachtalism.

G. Practical applications of heredity.
   1. Plants and animals.

(a) Numerous examples of improvement in plant and animal types.

2. Present day social problems.
   (a) Need for proper legislation.
   (b) General recognition and understanding of biological heredity.
   (c) What we as individuals may do towards race betterment.

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After using this method of presentation for some time, the writer has found the students' reaction to be distinctly favorable. Several have said that this unit was the most interesting part of the zoology course. Others have asked if it would be possible to offer a semester's course in the subject, stating that it was the most important in zoology. No difficulty has been met in discussing any of the topics in mixed classes. On the contrary, a wholesome attitude has existed and the frankness of their questions and responses has shown a fundamental grasp of the principles of evolution, heredity and eugenics and their social applications.

KILAUEA ON SCHEDULE.

Kilauea follows a regular cycle of activity, according to the studies of the late Prof. James D. Dana, one of the first to determine the unique features of the Hawaiian volcanoes. First the liquid lavas rise, filling up the crater and consequently raising its floor. This phase was reported during the past few months, culminating in Dr. T. A. Jaggar's bold but promptly fulfilled forecast of an eruption in 1929.

When the crater has filled there is a discharge of the lava through some conduit down the mountain-side. This is followed by a down-plunge of the crater floor undermined by the discharged material. Then follows another cycle beginning with the rising of the floor, which continues until the augmenting forces, from one source or another, are sufficient for another outbreak.—*Science News-Letter.*

"WHAT ARE THE CHANCES THAT. . ."

By Dr. Thornton C. Fry,

Member of the Technical Staff of Bell Telephone Laboratories, Author of "Probability and Its Engineering Uses."

Everybody asks this question; but not everybody understands how to answer it. In fact the attempt to find answers to questions of this sort has led to an entire branch of mathematics—the Theory of Probability. Of its many aspects, this short article considers only one: the reasons for expressing measurements of probability in the form in which they are ordinarily given.

In the first place, as every one knows, to measure anything there must first be a unit of measure. Also, although one thinks of this particular fact a little less often, there must be an agreement upon a method of dividing the chosen unit before one can measure magnitudes not exactly a unit in amount. In measuring length for example, (and the same is true of any other quantity), we must have a unit and we must agree upon a method of subdividing this unit. From a standpoint of common sense, it seems reasonable to have a scale of such a nature that when two like objects are placed end to end we shall find their combined length to be represented by just twice as great a number as the length of either one alone. Such a scale we call a "uniform scale."

The same ideas apply when we come to set up a scheme for measuring probability. Rather illogically, perhaps, we shall take up these two points in their inverse order, first discussing what we mean by a uniform scale of probability and then defining our unit of measure. An illustration will help in developing our ideas.

Imagine two men talking about Peary's trip to the North Pole, and one of them asking: "What is the chance that he got there on Sunday?" Obviously there is no point in asking this question if they know the answer, so we shall assume that they, like ourselves, are ignorant of the actual recorded day.

To this question we can not give a definite answer until we have defined our method of measuring probability, so we must do what we always do with unknown numbers: represent the desired answer by a letter, p. Next, we remember that, since we are in complete ignorance as to when Peary arrived at the

North Pole, the chance of his having reached there on Monday, or Tuesday, or any other day of the week, is the same as the chance of his having reached there on Sunday. All of these then are equally likely. In other words, we have seven *equally likely* possibilities.

If we had seven *equally long* objects, the length of each being l, we could begin to construct a uniform scale of length by putting two of them end-to-end and calling the resultant length $2l$; then adding on a third and calling the new length, $3l$; and so on. We ought, therefore, by making the proper use of our equally likely things, to be able to construct a uniform scale of probability. The only difficulty appears to be that of finding a suitable analogue for "end-to-end," and this difficulty can be resolved by a very simple observation.

If we ask, "What is the chance that he arrived on either Sunday or Monday," it seems just as natural to represent the answer by $2p$ as it does to represent the combined length of two of our like objects by $2l$. This relationship of "either-or" therefore occupies the same place in our thought processes regarding probability that "end-to-end" does in geometry. It is not *necessary* that we should represent the probability of his having arrived on either Sunday or Monday by the number $2p$, but it impresses us as a very *sensible* thing to do. Similarly, we say the chance of his having arrived on either Sunday, Monday, or Tuesday should be $3p$; the chance of his having arrived between Sunday and Wednesday $4p$, and so on. Finally, after we have put all of our equally likely things "end-to-end" in this way, we arrive at the conclusion that the chance of his having arrived on some one or other of the seven days of the week is $7p$. Beyond this point we cannot go—and herein lies one very fundamental difference between measuring probability and measuring length—for some one of these things *must* have happened. There are no further possibilities, and so $7p$ must be that number which represents certainty.

That is how we set up our uniform scale of probability. Now how shall we choose our unit of measure? As there is little to guide us in this matter, our choice must be more or less arbitrary, as it is in the choice of a unit of length. It has always seemed to me that the most suitable choice would be one which caused certainty to be represented by ∞, that is "infinity," for certainty is the biggest possible probability in

the same sense that ∞ is the biggest possible number. Yet, curiously enough, this is about the only symbol which we cannot use for certainty. For suppose we do: then we arrive at the conclusion in our Peary illustration, that $7p = \infty$. Then p must be one-seventh of infinity and since infinity is by definition a magnitude so great that its parts are also infinite, we come to the statement that $p = \infty$ too. Thus we become involved in the absurdity that the chance of his having arrived on Sunday is represented by the same symbol as certainty, though obviously we are not at all certain that he did. We must therefore admit—and for my part the admission is always made with a feeling of regret—that this choice will not do.

Among other numbers which might possibly represent certainty there is no one which has any greater claim than the number 1 itself. Therefore it has come about, that a thing is said to have a probability $1/n$ when we are sure that either it, or one of n-1 other equally likely things, is bound to happen. In our particular illustration we put $7p$ equal to 1, and conclude that the chance p of Peary having reached the North Pole on Sunday is just one-seventh.

This, then, is the exact answer to the question, "What are the chances that——" *It is a number read from a uniform scale of probability in which the unit of measure is certainty.*

The usual definition reads: "If of n possible cases, m are favorable to the occurrence of an event, and if all cases are equally likely, the probability that the event will occur is m/n."

As the "cases" spoken of in this definition are equally likely, the probability of any one may be represented by p. As only n are "possible"—which means that some one of them is sure to occur—we know that $np = 1$. Hence $p = 1/n$. Finally, if we consider the m "favorable" cases, their combined probability must be m/n; and as "favorable" merely means that our event always accompanies these "cases," and never happens otherwise, it follows that the probability which we seek is really m/n.

So the two definitions are equivalent after all, and we will get to the same result in the end whichever one we use. For myself, however, I like best the one to which this article has led us, for its seems to me to give us a somewhat clearer insight into what we really do when we answer the question, "What are the chances that——"

Sci Science Education vol 14: Nov. 1929

THE MATHEMATICS NEEDED IN HIGH SCHOOL PHYSICS.

By L. R. Kilzer,

University of Wyoming.

A survey of some recent investigations indicates the following conclusions:

1. The following factors are contributory to physics ability in the order named:
   - (a) Interest in physics.
   - (b) Simple mathematics of physics.
   - (c) Observation aptitude.
   - (d) Reading comprehension.
   - (e) Number series and logic.
2. In some of the high school physics classes, 25% of the pupils fail to make passing grades.
3. Certain mathematical abilities have greater value in predicting success in physics than have either reading ability or general intelligence.
4. There is very little agreement among teachers of physics in regard to the mathematical prerequisites for the elementary course in physics.
5. In a certain state, as many as 71% of the high schools require their pupils to take physics.
6. Almost half of the teachers of high school physics say that their pupils use their mathematics poorly.
7. Many teachers of high school physics omit a large number of the problems supplied by their textbook.

In view of these findings and many others not recorded here, an attempt was made to build an inventory test covering the mathematics needed in high school physics.

The specific purposes of this test are:

First, To point out to mathematics teachers those items in their subjects which are useful in high school physics, and to provide a means for testing pupils on these items.

Second, To assist the administration in guiding pupils in their choice of physics. (Other factors such as interest, observation aptitude, and reading comprehension no doubt enter also into prognosis.)

Third, To provide an inventory test to be given by the physics teacher during the first week of the physics course. (While this test is not strictly diagnostic, it is nevertheless valuable in pointing out many weak points and in indicating certain lines of attack for remedial work.)

A questionnaire was sent to a random sampling of 500 Iowa high schools in the fall of 1927 in order to ascertain the names of the high school physics textbooks most frequently used. Replies were received from 345 of these 500 high schools. On the basis of these replies it was found that only five textbooks are used in 2% or more of the schools. These textbooks, in alphabetical order, are: Black and Davis; Carhart and Chute; Dull; Fuller, Brownlee and Baker; Millikan and Gale (including Pyle's revision).

All the problems given in these five textbooks, together with their laboratory manuals, were solved by every reasonable method which the author of this article would expect high school pupils to solve the problems. All processes were then carefully recorded, and on the basis of the data thus obtained, a tentative edition of an inventory test was constructed. In order to hold the test down to such a length that it could be given in a laboratory period of 80 minutes, it was necessary to omit a few items that occurred only a few times. The test, however, provides an almost complete picture of the mathematics needed.

The tentative edition of the test consisting of Parts I and II, was given to 265 pupils in nine high schools. None of these pupils had taken physics but all were either eligible to take it when they took this test or otherwise they would be eligible to take physics the following semester. On the basis of results obtained by these 265 pupils the test was revised. Some items were omitted and others were slightly altered in the revised edition of the test. Part I of the revised edition concerns itself with items usually considered as belonging to arithmetic and algebra, while Part II consists of items usually considered as belonging to plane geometry and trigonometry. The item which obtained the largest percentage of correct responses comes first and the item which obtained the smallest percentage of correct responses comes last in each part of the test.

The revised edition of the test was given to 262 pupils in six high schools. None of these pupils took the tentative edition of the test. On the basis of results obtained by these 262 pupils, the reliability of the test as a whole was found to be $.904 \pm .008$, and the probable error of a raw score was found to be 1.4317. The total possible score is 90.

Tentative norms have been established. Briefly, these indicate that the score for the upper quartile is 62; the median score is 53; and for the lower quartile it is 44.

A few of the conclusions that are indicated by this study will be listed:

1. The mathematics needed in solving the problems of high school physics involves a considerable body of information usually taught in arithmetic, algebra and plane geometry. Not much trigonometry is needed.

2. Most of the mathematics needed in solving high school physics problems is not very difficult.

3. Most pupils who are eligible to take high school physics use their mathematics poorly.

4. There is definite need for maintenance drills covering the items and processes needed in physics.

5. There is considerable difference in the preparation of individual pupils on certain items and processes. The difference in preparation of different schools is nearly as great.

6. The mathematics department should make sure that its pupils are well prepared and well drilled on the items of this test.

7. At the beginning of the physics course it is advisable to give this test. It will show whether a pupil is weak or strong in the mathematics needed in high school physics and will point out certain lines of attack for remedial work.

8. It is probable that this test will have considerable value for prognosis, but the proof of this assumption awaits further experimentation.

In conclusion, it may be well to add that the "Inventory Test for the Mathematics Needed in High School Physics" is to be obtained from the Public School Publishing Company of Bloomington, Illinois. The writer's doctor's thesis at the State University of Iowa sets forth in detail the procedure and findings of this study.

WILLIAM JOHN COOPER, COMMISSIONER OF EDUCATION.

President Coolidge, with the advice and consent of the Senate, appointed William John Cooper, of California, to be commissioner of education in the Department of the Interior. He entered upon the duties of the office on February 11. Doctor Cooper was born in California in 1882, and his educational training as well as his principal educational experience has been in that State. He was graduated from the University of California in 1906, and received the master's degree in 1917 and the doctor's degree in 1928. After teaching and supervisory work in high schools of Stockton, Berkeley, and Oakland, he was superintendent of schools of Piedmont, Fresno, and San Diego, leaving the last named city in 1927 to become State superintendent of public instruction of California. Doctor Cooper has conducted classes in education in several universities and normal schools.

BACKGROUND AND FOREGROUND OF GENERAL SCIENCE.

By Wm. T. Skilling,

State Teachers' College, San Diego, Calif.

No. I. The Chemical Elements.

The question is often asked "Why do we think there are 92 elements in the universe, and *only* 92?" We have never found quite that many upon earth, and might there not be an unlimited number in other planets or in the sun, or at least in the infinity of the stellar system.

The most sensitive method of detection of elements is not by chemical means but by the use of the spectroscope. Helium owes its name to the fact that its spectral lines were discovered in the sun. Afterwards terrestrial helium was found and the usual chemical and physical tests applied to it.

There are as yet many unidentified spectral lines. Certain lines in the spectrum of the outer atmosphere of the sun have been attributed to a hypothetical element which has been given the name "coronium." But that any such element exists is highly improbable. The lines may be caused by some well known element which in the exceedingly rarefied gases of the corona are capable of giving a spectrum which under laboratory conditions cannot be duplicated. It is well known that under different conditions of temperature and pressure gases give very different spectra.

The above supposition in regard to "coronium" is made more plausible by the recent discovery by Dr. I. S. Bowen that the hypothetical element, nebulium, thought to exist in the gaseous nebulae is nothing but oxygen and nitrogen under conditions and in quantities that we cannot reproduce.

To date ninety elements have been discovered, and theory would indicate that two more exist. Enough is known about the structure of the atom to give each element a number which fixes its place among its sister elements, and likewise goes far toward indicating its properties.

Hydrogen, the lightest element, is number one because its nucleus possesses one net positive charge of electricity. The fact that it has only one external electron would also give hydrogen its number one. Uranium, the heaviest atom, is number 92 for its nucleus has a net positive charge of ninety-two and there are ninety-two planetary electrons external to the nucleus.

The serial number of each of the ninety known elements has

been assigned to it. The brilliant young scientist, Moseley, led the way in this classification of the elements according to the unerring criterion of their characteristic X-ray spectra.

When each of the known elements has been given its place two blanks appear at numbers 85 and 87. Probably nature has material somewhere to fill these blanks, and judging by the rate at which other such gaps have been filled within the last few years it will not be long until the table is complete from 1 to 92.

There is, then, no room for another element in excess of this number unless its atom should be heavier than that of uranium. An element lighter than hydrogen could scarcely exist for hydrogen has the smallest possible number of electrons.

All of the heavier atoms are radio active. That is, their nuclei are disintegrating and they are being converted into elements of lower atomic weight. Atoms still heavier than uranium would, it is thought, be still less stable than these. There is no positive proof that such elements may not be possible somewhere, but if they were present upon earth they would probably have been detected by reason of their radio active properties. Madame Curie detected radium thus though disguised by great quantities of pitchblende with which it was mixed.

Such facts and theories as those discussed above are useful in giving scientific perspective though no direct use be made of them. An extensive background of knowledge is more essential to the teacher of General Science than to the teacher of a specific branch such as chemistry, physics, botany or physiology.

But if such is the background of knowledge concerning the elements what should be brought out into the foreground and presented to the pupils of eighth or ninth grade?

In the first place we should remember that only about 20 of the elements enter in any important way into the life of a child or, for that matter, an adult. The following ten elements constitute nearly 99 per cent of the surface of the earth and are for that reason of interest: Oxygen, Silicon, Iron, Calcium, Sodium, Hydrogen, Carbon, Aluminum, Magnesium, Potassium. The following all are of special interest though their total amounts to but one per cent of the crust of the earth: Chlorine, Nitrogen, Phosphorus, Sulphur, Copper, Gold, Silver, Tin, Nickel, Zinc.

A collection of these twenty should be made, in the elemental form as far as possible, and in simple compounds if the element cannot be obtained free. When compounds are used in this illustrative material a clear distinction should be maintained

between the compound and the element which it represents.

Metals and nonmetals also, should be distinguished from one another, not by technical definitions, but by observing apparent differences.

If specimens are at hand a study of the nature and uses of each element will be very interesting and may be carried on as long as time will permit.

Since nearly half of the above listed elements are in themselves useful metals their study will naturally lead into the subject of metallurgy and ore reduction. Such matter presented with sufficient simplicity and with the aid of some illustrative material will throw the light of new information on many things which come within the everyday experience of boys and girls.

ULTRAVIOLET IN COUNTRY.

The amount of ultraviolet light in the country is actually half again as great as in the city. This has been known or suspected in a general way for some time, but now scientific proof of it has been made by J. H. Shrader, H. H. Coblentz and F. A. Korff, working at the Baltimore Department of Health. The figure reported is the result of actual measurements, based on chemical tests. They were made in the center of the city, in nearby suburbs located about three miles from the city's center, and in the country on farms ten miles from the municipal center.

Measurements of the amount of dust polluting the air were made at the same spots. These showed that air pollution affects the amount of ultraviolet light. The pollution was heaviest in the city and diminished to a figure about one-sixth as great in the country. The amount of dust settled on the top of skyscrapers was less than the amount at the street level, and the amount of ultraviolet light on the top of the buildings was greater than that at the street level.

The kinds of dust polluting the air were examined. Carbon, in the form of tarry products, kept out more of the ultraviolet light than ordinary dust or street sweepings.—*Science News-Letter.*

MANY HIGH-SCHOOL GRADUATES CONTINUE STUDIES.

Approximately 48.3 per cent of the 40,000 graduates of Pennsylvania high schools for the school year 1927-28 are continuing their education, according to announcement of the State department of public instruction. Of this number, about 26.8 per cent have entered higher institutions, 12.9 per cent are in teacher-training schools, 4 per cent in nurse-training schools, 3.6 per cent have entered commercial schools, and 1 per cent are taking post-graduate courses in the high schools. It is estimated that 8.5 per cent of the class of 1928 have remained at home, and no record is given for 8.9 per cent of those graduating. The remainder are engaged in commercial pursuits, agriculture, factory work, trade, or other occupations. The number of graduates of public high schools in Pennsylvania has more than doubled during the past eight years, increasing from18,796 in 1920 to approximately 40,000 in 1928.

THE FIRST QUARTER-CENTURY OF THE MATHEMATICS SECTION OF THE CENTRAL ASSOCIATION.

By Edwin W. Schreiber,

Ann Arbor, Mich.

What hath the Mathematics Section wrought since the turn of the century? If the twenty-eight volumes of School Science and Mathematics were on the shelves of our study or den, we might leaf through the many thousand pages and find an answer to the question. However, the "if" in most cases is such a big one, especially for the young teacher of high school mathematics, that a satisfactory answer would be well-nigh impossible. In my own case I had to resort to two large university libraries (Michigan and Chicago) to make the story complete. There are many members of our Association, and particularly those of the Mathematics Section, who will be interested in reviewing the programs presented at our annual meetings. Who are the men and women that have fostered progressive teaching of secondary mathematics in the Central West? You will find the answer in the "Who's Who" at the close of this record. It is not my purpose to evaluate the record nor to interpret it—simply to present it as a continuous story in the space of a few pages. Let the record speak for itself. The reader can make his own deductions.

1. 1902, Nov. 28, Lewis Institute, Chicago. The first regular meeting of the Central Association of Physics Teachers. "Physics and Mathematics," by Prof. E. H. Moore, University of Chicago.
2. 1903, Apr. 10-11, Armour Institute, Chicago. The first regular meeting of the Central Association of Science and Mathematics Teachers. There is no printed record of the Math. Section officers nor of the program.
3. 1903, Nov. 27-28, Northwestern Professional School Building, Chicago. There is no printed record of the Math. Section officers or program.
4. 1904, Nov. 25-26, Northwestern Professional School Building, Chicago. Math. Section Officers: Chairman, C. E. Comstock. Secretary, Mrs. B. E. Page. Program: Some Problems Confronting the Leaders of Geometry—C. W. Sutton. A High School Mathematics Club—C. W. Newhall.

   The Introduction of Meteorology into the Course of Instruction in Mathematics and Physics—Prof. Cleveland Abbe.

Progress in Correlation of Physics and Mathematics—F. L. Bishop.

5. 1905, Dec. 1-2, Central Y. M. C. A., Chicago.
   Math. Section Officers: Ch., H. E. Cobb. V-Ch., J. V. Collins. Sec., Mabel Sykes. Program: The Prussian Schools, H. E. Cobb (A letter from Germany).
   The Straight line in Geometry—Prof. J. W. Withers.
   A Combined Course in Algebra and Physics at F. W. Parker School, W. S. Bass
   Practical Problems in Geometry—Mabel Sykes.
   Interest and Progress in the Teaching of Mathematics, N. J. Lennes.
   Aims in Algebra Teaching—Prof. H. E. Slaught.
   Some Thoughts on the Teaching of Geometry—C. A. Pettersen.
6. 1906, Nov. 30-Dec. 1, University of Chicago.
   Officers: Ch., J. V. Collins. V-Ch., H. E. Slaught. Sec., Mabel Sykes.
   Program: Personal Observations of the Teaching of Mathematics in German Schools—H. E. Cobb.
   Current Tendencies in Secondary Mathematics in Italy and France—Dr. J. W. A. Young.
   The Teaching of Mathematics in Wisconsin—Prof. E. B. Skinner.
   The Teacher of Mathematics—Prof. H. L. Coar.
   Changes in Teaching of a Course in Mathematics that will Aid in Keeping Boys in High School—Prin. H. B. Loomis.
   Report of the Committee on Teaching of Geometry—G. W. Greenwood.
7. 1907, Nov. 29-30, McKinley High School, St. Louis, Mo.
   Officers: Ch., H. E. Slaught. V-Ch., J. C. Stone. Sec., Mabel Sykes.
   Program: Lessons Drawn from the History of Science—Florian Cajori. Report of Committee on Algebra in the Seconday Schools—Chas. Ammerman. Discussion—F. Cajori, E. R. Hedrick, W. W. Hart, G. B. Halsted, H. E. Cobb, H. E. Slaught.
   Report of Committee on Geometry—G. W. Greenwood.
   Discussion—G. B. Halsted, G. C. Shutts, C. W. Newhall.
8. 1908, Nov. 27-28, Englewood High School, Chicago.
   Officers: Ch., J. C. Stone. V-Ch., Chas. Ammerman. Sec., Mabel Sykes.

Program: Report of Committee on Unification of Secondary Mathematics—H. E. Cobb.

Discussion—S. C. Davison, G. W. Meyers, W. W. Hart.

Third Report of Committee on Geometry—G. W. Greenwood.

Discussion—Mabel Sykes, M. W. Coultrap, G. B. Halsted.

Report of Committee on Algebra—Chas. Ammerman.

Discussion—G. B. Halsted.

9. 1909, Nov. 26-27, University of Chicago.

Officers: Ch., Chas. Ammerman. V-Ch., C. A. Pettersen. Sec., Mabel Sykes.

Program: Preliminary Report of Committee on Real Applied Problems in Algebra and Geometry—J. F. Millis.

Discussion—G. A. Harper, J. A. Foberg, C. I. Palmer, H. E. Slaught.

Second Report of Committee on the Unification of Secondary Mathematics—H. E. Cobb.

Discussion—R. L. Short, H. E. Slaught.

The Work of the International Commission on the Teaching of Mathematics—J. W. A. Young.

10. 1910, Nov. 25-26, Case School of Applied Science and the Technical High School, Cleveland, Ohio.

Officers: Ch., C. A. Pettersen. V-Ch., R. L. Short. Sec., Mabel Sykes.

Program: Fundamental Reasons for Teaching High School Mathematics—Prof. David Eugene Smith.

Report of Committee on Fundamentals—I. S. Condit.

Report of Committee on a Uniform System of Notation in Mathematics and the Sciences—L. P. Jocelyn.

Report of Committee on Results—C. E. Comstock.

Aims and Tests in Algebra—H. L. Terry.

Second Report of Committee on Real Applied Problems —J. F. Millis.

Discussion—Marie Gugle, W. E. Stark.

11. 1911, Dec. 1-2, Lewis Institute, Chicago.

Officers: Ch., R. L. Short. V-Ch., I. S. Condit. Sec., Marie Gugle.

Program: Report of Committee on Results—C. E. Comstock.

Discussion of Report—Chas. Otterman.

The Application of Mathematics to Problems of the Shop—K. G. Smith.

The Significance of the Real Problem in Secondary Mathematics, C. W. Newhall.

Report of Committee on Uniform Notation—L. P. Jocelyn.

12. 1912, Nov. 29-30, Northwestern University, Evanston, Illinois.

Officers: Ch., I. S. Condit. V-Ch., C. W. Newhall. Sec., Marie Gugle.

Program: Report of Committee on Results—C. E. Comstock.

Review of the Teaching of Mathematics for the Past Ten Years, W. W. Hart.

Mathematics and the Vocational School—R. L. Short.

The Preparation of Teachers of Mathematics—J. V. Collins.

Report of Committee on Uniform Notation—L. P. Jocelyn.

13. 1913, Nov. 28-29, East High School, Des Moines, Iowa.

Officers: Ch., C. W. Newhall. V-Ch., H. L. Terry. Sec., Marie Gugle.

Program: Report of Committee on Vocational Mathematics—R. L. Short.

Discussion—Prof. A. G. Smith.

Introduction to Geometry—P. D. Smith.

Courses at Lewis Institute—A. W. Cavanaugh.

Report of Committee on Results—C. E. Comstock.

Traditional Examinations in Mathematics—Mrs. J. P. Anderson.

A New Marking System and Means of Measuring Mathematical Ability—Prof. Florian Cajori.

14. 1914, Nov. 27-28, Hyde Park High School, Chicago.

Officers: Ch., H. L. Terry. V-Ch., Edith Long. Sec., Marie Gugle.

Program: The Elements of a Successful Recitation—R. E. Krug.

Observations of the Teaching of Mathematics—J. C. Hanna.

The Training of Teachers of Mathematics—G. A. Miller.

Report on Teaching of Mathematics in Germany—W. W. Hart.

Report on Vocational Mathematics—K. G. Smith.

15. 1915, Nov. 27-28, Harrison Technical High School, Chicago.

Officers: Ch., Edith Long. V-Ch., J. W. A. Young. Sec., Marie Gugle.

Program: Report on Correlations of Secondary Mathematics—Edna Allen.

Current Educational Movements and General Mathematics —G. W. Meyers.
Report on Vocational Mathematics—K. G. Smith.
History of Algebra—Prof. L. C. Karpinski.
Report of Committee on Geometry—E. R. Breslich.

16. 1916, Dec. 1-2, University of Chicago.
Officers: Ch., J. W. A. Young. V-Ch., F. C. Touton. Sec., Marie Gugle.
Program: The Fundamentals of Algebra—E. J. Wilczynski.
Report of Committee on Geometry—E. R. Breslich.
Report of Committee on Publicity—Edith I. Atkin.
Modern Developments in Elementary Mathematics—G. A. Miller.
Report on Correlation—Edna Allen.
Report on Vocational Mathematics—K. G. Smith.

17. 1917, Nov. 30-Dec. 1, Ohio State University, Columbus, Ohio.
Officers: Ch., W. W. Hart. V-Ch., J. A. Foberg. Sec., Edith I. Atkin.
Program: What Course of Study Should be Taken by a Boy or Girl in High School—Prof. Harris Hancock.
Report of Committee on Mathematical Requirements—J. A. Foberg.
Measurement of Products of Teaching High School Mathematics, S. A. Courtis.
Report of Committee on First Year Mathematics.

18. 1918, Nov. 29-30, University of Chicago.
Officers: Ch., J. A. Foberg. V-Ch., B. Cosby. Sec., Edith I. Atkin.
Program: Mathematics in the War—Prof. L. E. Dickson.
Education of Today—Prin. W. B. Owen.
High School of Tomorrow—W. W. Hart.
Report of Sub-Committee on Content of Course in First Year Mathematics—Mabel Sykes.

19. 1919, Nov. 28-29, Lake View High School, Chicago.
Officers: Ch., B. Cosby. V-Ch., M. J. Newell. Sec., Elsie Parker.
Program: Some Problems for the School Room from the Orientation Work of the A. E. F.—C. A. Epperson.
Report of the Sub-Committee of the National Committee on Reorganization of the First Course in Secondary Mathematics—J. A. Foberg.

The Organization of a National Council of Secondary Mathematics Teachers—C. M. Austin.

The Classification of Students According to Ability Shown in Psychological Tests—W. D. Reeve.

Note: The following delegates to represent this Section at the First Meeting of the National Council of Secondary Mathematics Teachers at Cleveland were appointed: H. E. Slaught, Mabel Sykes, W. W. Hart, C. E. Comstock, W. E. Beck.

20. 1920, Nov. 26-27, Englewood High School, Chicago.

Officers: Ch., M. J. Newell. V-Ch., W. E. Beck. Sec. Elsie Parker.

Program: The Fundamental Unit of Length in the United States—Edwin W. Schreiber.

The Results of Homogeneous Classification of High School Students—W. D. Reeve.

The National Council of Mathematics Teachers—C. M. Austin.

Present Work and Outlook of the National Committee on Mathematical Requirements—J. A. Foberg.

The Mechanics of the Classroom—Marx Holt.

The Value of Mathematics in the High School Course—W. J. Ryan.

Note: This Section voted to become an Institutional Member of the National Council of Teachers of Mathematics.

21. 1921, Nov. 25-26, Soldan High School, St. Louis, Mo.

Officers: Ch., W. E. Beck. V-Ch., Alfred Davis. Sec., Elsie Parker.

Program: No printed report of the program appeared in SCHOOL SCIENCE AND MATHEMATICS.

22. 1922, Dec. 1-2, Hyde Park High School, Chicago.

Officers: Ch., W. G. Gingery. V-Ch., E. L. Thompson. Sec., Gertrude Anthony.

Program: The Organization of Secondary Mathematics—W. W. Hart.

Accuracy in English, Mathematics, and Astronomy Grades, E. J. Moulton.

The Slide Rule—W. W. Gorsline.

Preparation of Teachers of Mathematics in the Junior High School—J. R. Overman.

23. 1923, Nov. 30-Dec. 1, Shortridge High School, Indianapolis, Indiana.

Officers: Ch., E. L. Thompson. V-Ch., A. M. Allison. Sec., Gertrude Anthony.
Program: Geometrical Figures in Nature—Edith Inks.
Study of Problems Connected with the Teaching of Mathematics, W. W. Hart.
Hurdles, A Device for Determining the Degree of Mastery, Kate Wentz.
The Slide Rule in Secondary Schools—W. W. Gorsline.
Mathematics Courses in the Senior High School—Fisk Allen.

24. 1924, Nov. 28-29, Nicholas Senn High School, Chicago.
Officers: Ch., A. M. Allison. V-Ch., R. Schorling. Sec., A. Blanche Clark.
Program: The Value of Verbal Problems in Algebra—J. M. Kinney, C. M. Austin.
Factors in the Pupil's Reaction to Mathematics—Olice Winter.
Arithmetic in the Junior High School—L. W. Colwell.
Algebra in the Junior High School—E. C. Hinkle.
A Study of the Factors of Success in First Year Algebra, E. W. Schreiber.
Geometry in the Junior High School—J. T. Johnson.
Report of an Experiment with Correlated Mathematics in a Large High School—P. R. Pierce.

25. 1925, Nov. 27-28, University of Chicago.
Officers: Ch., R. Schorling. V-Ch., E. W. Owen. Sec., A. Blanche Clark.
Program: Individual Instruction in a Course in Demonstrative Geometry—Mary Potter.
The Wisconsin High School Plan—W. W. Hart.
Individual Instruction in the First Year of Algebra—Selma A. Lindell.
What May be Done by Way of Diagnosis and Remedial Treatment in Arithmetic—L. H. Schnell.
Individual Instruction—E. R. Breslich, J. Gonnelly, E. W. Schreiber.

26. 1926, Nov. 26-27, Crane Junior College, Chicago.
Officers: Ch., E. W. Owen. V-Ch., J. A. Nyberg. Sec., A. Blanche Clark.
Program: The Writing and Choosing of Mathematical Text Books—Prof. R. D. Carmichael.
Impressions of My Study of Mathematics—By Three Students, Geo. Mahin, F. N. Whaley, Chaloner McNair.

Evaluating Materials Adjusted to Varying Abilities When Used with a Group of Unclassified Pupils—Raleigh Schorling.

27. 1927, Nov. 25-26, Cass Technical High School, Detroit, Michigan.

Officers: Ch., J. A. Nyberg. V-Ch., E. W. Schreiber. Sec., Margaret Dady.

Program: Adjusting the Course of Study in Ninth Grade Mathematics to the Ability of the Pupil—Hildegarde Beck.

Functional Analysis of a Unit of Work in Ninth Grade Mathematics—Charles A. Stone.

An Investigation of Achievements in Plane Geometry—F. A. Burroughs.

28. 1928, Nov. 30-Dec. 1, University of Chicago.

Officers: Ch., E. W. Schreiber. V-Ch., Martha Hildebrandt. Sec., Margaret Dady.

Program: Worthwhile Literature in the History of Mathematics Desirable for the Teacher in Secondary Schools —Prof. L. C. Karpinski.

The Drift in Junior High School Mathematics—Mary Potter. Discussion led by Martha Hildebrandt.

Mathematics in Industry—C. J. Leonard. Discussion led by Marx Holt.

Mathematics and the Progress of the Sciences—Prof. L. C. Karpinski.

(The last paper was presented on the General Program.)

Who's Who.

Abbe, C., P04
Allen, Edna, R15, R16
Allen, Fisk, P23
Allison, A. M., V-Ch23, Ch24
Ammerman, C., R07, R08, V-Ch08, Ch09, A. Tr13
Anderson, Mrs. J. P., P13
Anthony, Gertrude, Sec22, 23
Atkin, Edith I., R16, Sec17, 18, Cor. Sec21
Austin, C. M., P19, P20, P24
Bass, W. S., P05
Beck, Hildegarde, P27
Beck, W. E., V-Ch20, Del20, Ch21
Bishop, F. L., P04
Breslich, E. R., R15, R16, P25, V-Pr26, Pr27
Burroughs, F. A., P27
Cajori, F., P07, D07, P13, HM13
Carmichael, R. D., P26
Cavanaugh, A. W., P13, G. Sec15, G. Sec16, 17, 18
Clark, A. Blanche, Sec24, 25, 26
Coar, H. L., P06
Cobb, H. E., Ch05, P05, P06, D07, R08, R09, Pr11, 12
Collins, J. V., V-Ch05, Ch06, P12
Colwell, L. W., P24
Comstock, C. E., Ch04, Pr07, R10, R11, 12, 13, Del20
Condit, I. S., R10, V-Ch11, Ch12, A. Sec13
Cosby, B., V-Ch18, Ch19
Coultrap, M. W., D08
Courtis, S. A., R17
Dady, Margaret, Sec27, 28, 29
Davis, A., V-Ch21, Pr22
Davison, S. C., D08
Dickson, L. E., P18
Epperson, C. A., P19
Foberg, J. A., D09, R17, V-Ch17, Ch18, R19, R20, Pr20
Gingery, W. G., Ch22, Tr24, 25, 26, 27

Note: In the above, the key to the abbreviations is as follows:
D, P, R mean Discussion, Paper, Report.
Ch, V-Ch, Sec mean Chairman, Vice-Chairman, Secretary.
Pr, V-Pr, SEC, Tr mean President, Vice-Pres., Secretary, Treasurer of the Association.
Del—Delegate to the National Council, 1920.
HM—Honorary Member.

MORE MENTAL DOCTORS.

A great shortage of physicians who are familiar with psychiatry exists in the United States, according to recent testimony of Dr. William A. White, superintendent of St. Elizabeth's Federal Hospital for the Insane, before the House Committee on Appropriations.

The number of physicians in the country, Dr. White said, approximated 149,000, of which only 2,000 were thoroughly familiar with the treatment of mental diseases.

Against this figure, he puts the fact that "there are 800,000 beds in all the hospitals of the country. Four hundred thousand, or one-half of these, are in mental-disease hospitals."—*Science News-Letter*,

A BOYLE'S LAW APPARATUS OF IMPROVED DESIGN.

By W. L. Kennon,

University of Mississippi, University, Miss.

The present form of Boyle's Law Apparatus[1] was designed by the writer with a view to avoiding a number of objectionable features which appear to him to be inherent in what might be called the conventional forms of this apparatus. Several of the most serious objections to the conventional forms grow out of the use of mercury in rubber connecting tubes. The sulphur used in vulcanizing the rubber blooms and contaminates the mercury in a very short time. Furthermore, because of the considerable pressure of the mercury column it is necessary to attach the rubber tubing very securely to the glass terminals of the apparatus. This is generally accomplished by stretching the rubber tubing over enlargements in the glass tubes. Under these circumstances the rubber will split in a comparatively short time; and to avoid the serious results of this contingency must be replaced from time to time, an operation which is not only troublesome and time consuming but which affords a good opportunity to spill at least some of the mercury and to soil the remainder. Again the air bubbles which become entrained in the mercury column in the rubber tubing are much more difficult to remove than is generally supposed, and since they cannot be seen one is never assured of their removal.

In the forms of apparatus modeled after the familiar "J-Tube" it is necessary to pour mercury back and forth, which in the hands of the average student almost certainly results in the spilling and soiling of more or less mercury. Other short-comings will occur to those who have used this type of apparatus in the general physics laboratory. Other designs which have attempted to obviate these objections by avoiding the use of mercury have sacrificed that accuracy and directness of method so desirable in apparatus intended for educational purposes.

The features claimed for the present design are as follows:

1. A high order of accuracy for the type of construction used. The illustrative experiment given, which is typical, shows an average error of less than one-fifth of one per cent. This error is too small to be observable on a carefully plotted note-book graph.

[1]Manufactured by the W. M. Welch Manufacturing Company, Chicago.

2. Mercury is never in contact with rubber.

3. Mercury never has to be handled, once the apparatus is prepared for use. In preparing the apparatus for use the mercury may be introduced in a way to avoid entraining air bubbles; yet any air bubbles which happen to be entrained may be seen and removed.

4. It is immediately ready for use even after being set aside indefinitely. When not in use the mercury column may be completely protected from contamination, and is almost as completely protected when in use.

5. Only a comparatively small amount of mercury is required (about 225 gms.).

6. Protective devices are provided against expelling mercury from the apparatus by the use of excessive pressure, and of spoiling the adjustment of the mercury columns if the pressure is diminished beyond the minimum that may be sustained in the open arm.

7. The total range of pressure (using about 20 cm. air column) in the form of apparatus used here which is provided with scales 80 cms. long is approximately 100 cms. of mercury column. The illustrative experiment shows a range from approximately 60 cms. above atmospheric to 35 cms. below. In this experiment the total range possible was not used. This range of pressure is sufficient, when plotted in the usual way, to show the hyperbolic form of the pressure-volume curve. The pressure range may be considerably increased by using a shorter air column. The overall height of the apparatus is one meter.

8. Pressure is measured directly by the principle of "hydrostatic columns." Also the use of the open and closed manometers in conjunction affords a good opportunity to make this a special aspect of the experiment.

9. The construction is particularly rugged and durable. The glass manometer tubes are made of standard barometer tubing for which the iron frame provides substantial housing.

10. The apparatus is readily available for the measurement of pressures in other experiments, either as an open or closed manometer.

Of course, all the features listed are not exclusive to this form of apparatus. It is claimed, however, that all the desirable features of the conventional forms are preserved to the exclusion of their undesirable elements, and that the apparatus has certain inherent merits not possessed by the usual types.

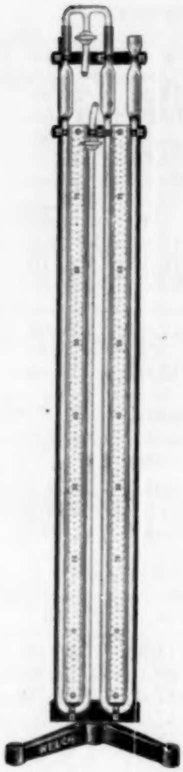

FIG. 1

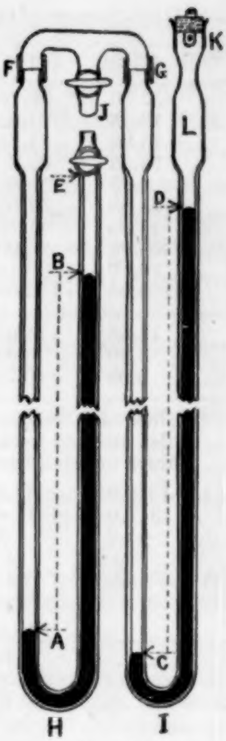

Fig 2

Figure 1 shows the general appearance of the apparatus; and Fig. 2, the principle of construction and operation. It will be observed that the apparatus consists essentially of a closed manometer H (Fig. 2), and an open manometer I in communication. The pressure is varied by means of a simple air-pump attached at J. The maximum pressure is applied and after disconnecting the pump the pressure is diminished to atmospheric pressure in about eight approximately equal stages by carefully opening the cock J. The pump is then connected for diminished pressure and the minimum pressure produced which may then be increased in stages to atmospheric pressure by means of the cock. The pump is, therefore, required but twice during the experiment.

Should careless manipulation result in forcing the mercury arm at C around the bend, the mercury in this manometer will be "blown" into the bulb L. The ample volume of this bulb togeth-

DATA SHEET—ILLUSTRATIVE EXPERIMENT.

Trial	1	2	3	4	5	6
A	27.50	26.40	25.15	23.20	21.45	20.10
B	13.55	14.65	15.90	17.80	19.60	20.90
A ±B	−13.95	−11.75	− 9.25	− 5.40	− 1.85	+ .80
C	75.55	67.30	59.40	49.85	42.70	38.00
D	1.75	9.65	17.20	26.50	33.45	38.00
C ±D	+ 73.80	+ 57.65	+ 42.20	+23.30	+ 9.25	.00
A ±B°	− 13.95	− 11.75	− 9.25	− 5.40	− 1.85	+ .80
H	+ 59.95	+ 45.90	+ 32.95	+17.90	+ 7.40	+ .80
Bar	+ 76.10	+ 76.10	+ 76.10	+76.10	+76.10	+76.10
P	+136.05	+122.00	+109.05	+94.00	+83.50	+76.90
B°	13.55	14.65	15.90	17.80	19.60	20.90
E	3.90	3.90	3.90	3.90	3.90	3.90
V	9.65	10.75	12.00	13.90	15.70	17.00
Log. P	Values omitted because of limited space.					
Log. V	Vales omitted because of limited space.					
Log. PV	Values omitted because of limited space.					
PV	1312.9	1311.5	1308.6	1306.6	1311.0	1307.6
mPV	1311.0	1311.0	1311.0	1311.0	1311.0	1311.0
dm	+1.9	+.5	−2.4	−4.4	0.0	−3.4

Trial	7	8	9	10	11
A	5.10	8.80	11.80	15.10	18.35
B	35.55	32.00	29.10	25.80	22.65
A ±B	+ 30.45	+ 23.20	+17.30	+10.70	+ 4.30
C	5.25	11.60	17.25	24.55	32.80
D	70.40	64.15	58.60	51.35	43.20
C ±D	− 65.15	− 52.55	−41.35	−26.80	−10.40
A ±B°	+ 30.45	+ 23.20	+17.30	+10.70	+ 4.30
H	− 34.70	− 29.35	−24.05	−16.10	− 6.10
Bar	+ 76.10	+76.10	+76.10	+76.10	+76.10
P	+ 41.40	+ 46.75	+52.05	+60.00	+70.00
B°	35.55	32.00	29.10	25.80	22.65
E	3.90	3.90	3.90	3.90	3.90
V	31.65	28.10	25.20	21.90	18.75
PV	1310.3	1313.7	1311.6	1314.0	1312.5
mPV	1311.0	1311.0	1311.0	1311.0	1311.0
dm	−.7	+2.7	+.6	+3.0	+1.5

Average departure from mean ignoring sign 2.11.
Average percentage variation from mean 0.16%.

A, B, C, D, E, = Scale readings at points indicated, see Fig. 2.
A ±B and C ±D = Differential pressures in cms. of mercury in two manometers.
A ±B° and B° = Previous values brought forward for convenience.
V = B° − E, mPV = mean or average value of PV., dm = departure of PV from mean value.

Remark: Experiment conducted under normal laboratory conditions. No provision was made to control temperature which varied from 23°C to 24°C during the course of the experiment.

er with the little device[2] at L prevents any mercury being expelled from the apparatus. The mercury column may then be assembled in a few minutes by removing the stopper K and introducing a soft iron wire into the bore of the tube. If it becomes necessary to remove the rubber connection at G in order to reassemble the mercury this is a simple matter. Such a mishap as described will not break the mercury column in H; and in any event, is not likely to occur except through gross carelessness, since an expansion chamber which is provided in the pump line enables the operator to apply the pressure at a very uniform rate. In a similar manner protection is afforded against excessively low pressures by the bulb at G.

The data sheet below shows the order of observations and their reduction.

[2]This consists of a tight fitting stopper through which a glass tube with sealed end and hole blown in side is introduced.

RAYON—A CHEMICALLY-MADE YARN RIVALING THE SILKWORM'S PRODUCT.

By Dr. R. E. Rose.

A chemist pondered upon the fact that a silkworm caterpillar ate mulberry leaves and spun skin. It was a challenge to him and he felt that a chemist should be able to chew up something in a bottle or kettle and spin a thread just as good as that of the caterpillar. It took a long time to realize that dream but now we know rayon as well as we do cotton and silk and the amount made runs to hundreds of millions of pounds annually.

It really is chemically very little different from cotton from which it can be made but it is quite different in its appearance and some other properties. If you want to make an old cotton sheet into rayon you can do it. Soak the sheet in strong caustic soda solution, squeeze out most of the lye, tear the sheet all to pieces so that it forms crumbs. Beat up the "ripe" crumbs with carbon disulfide, a liquor of an atrocious odor, poisonous and extremely inflammable, more so than gasoline. A bright orange rather sticky mass will be all that remains of the sheet. Dissolve this in water with a little more lye in it. Adjust its thickness until it is just right, get all the tiny air bubbles out of it, also every bit of dirt. Then force through platinum plates with tiny holes in them into an acid bath. Filaments will result and these, after many other treatments, such as washing, freeing from sulphur and bleaching, will appear, after spinning, as rayon yarn. On the whole it is easier to use the old sheet as rags and buy your rayon.

Thus is the caterpillar no longer unrivaled in the art of making lustrous fibres out of vegetable matter, although it has certain trade secrets that are still outside the range of the chemist's present achievements. It is true that no fisherman would like to use a rayon line, but his daughter finds rayon indispensable in making her wardrobe up-to-date.

THE ARRANGEMENT OF THE ELECTRONS IN THE OUTER PORTION OF THE ATOM*.

By Walter O. Walker,

William Jewell College, Liberty, Mo.

The Wave Theory of Schroedinger.

Bohr has stated that an electron does not lose energy while rotating in its orbit, but that in order to accomplish this it must move from an outer to an inner orbit. This means that energy must be emitted in definite quanta and not continuously. This, is, in the mind of Schroedinger, an insurmountable obstacle to the acceptance of the Bohr theory. The greatest justification for the Bohr atom was that it worked.

The Schroedinger conception is highly mathematical. Only a brief summary of its essential points will be given here.

Assumptions.

(1). The charge is spread everywhere throughout the volume of a sphere of atomic diameter.

(2). This sphere must apparently surround the nucleus of the atom.

(3). The charge does not move about. It does change in intensity at different points in the sphere at different times. This fluctuation in the strength of the field sets up light waves in the surrounding space.

(4). The sphere throws off a small portion of itself, a little bunch of vibrating energy, which represents the electron. Perhaps later this portion of energy adds itself to another atomic mass of energy.

(5). This atomic model does everything that the Bohr model does and yet does not violate established electrical principles.

The writer does not care at the present time to hazard an opinion regarding the relative merits of the Schroedinger and Bohr theories. Perhaps later a paper may be offered setting forth in detail the merits of the Schroedinger atom. Fig. 4 represents the present conception of an atom with an electron being ejected.

The Lewis-Langmuir Theory.

The Lewis-Langmuir theory of the arrangement of the electrons in the outer portion of the atom is primarily a chemical one. It has been designated variously as the theory of the "cubical atom," the theory of the "static atom," and the "octet theory."

* The first section of this article was published in the March number.

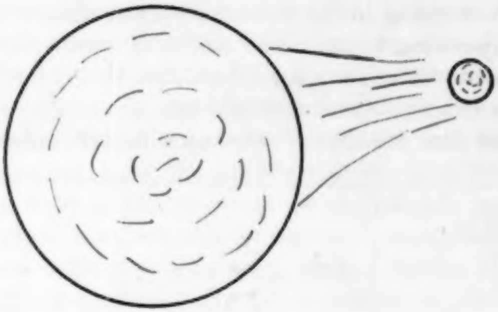

FIG. 4.
A conception of the hydrogen atom according to the Schroedinger theory.

The various points in the theory have been summarized by Langmuir in the following.

(1). The electrons in atoms are either stationary or they rotate, revolve, or oscillate about definite positions in the atom. The electrons of the most stable atoms, namely, those of the inert gases, have positions symmetrical with respect to a plane called the equatorial plane, passing through the nucleus at the center of the atom. No electrons lie in the equatorial plane. There is an axis of symmetry (polar axis) perpendicular to the plane through which four secondary planes of symmetry pass, forming 45° angles with one another. These atoms thus have the symmetry of a tetragonal crystal.

(2). The electrons in a given atom are distributed through a series of concentric (nearly) spherical shells, all of equal thickness. Thus the mean radii of the shells form an arithmetical series 1, 2, 3, 4, and the effective areas are in the ratios of 1, 4, 9, 16.

(3). Each shell is divided into cellular spaces or cells occupying equal areas in their respective shells and distributed over the surface of the shells according to the symmetry required by postulate 1. The first shell thus contains 2 cells, the second 8, the third 18, and the fourth 32.

(4). Each of the cells in the first shell can contain only one electron, but each other cell can contain one or two. All of the inner cells must have their full quotas of electrons before the outside cells can obtain any. No cell in the outside layer can contain two electrons until all of the other cells in this layer contain at least one.

(5). Two electrons in the same cell do not attract or repel one another with strong forces. This probably means that there is a magnetic attraction (Parson's Magneton theory) which nearly counteracts the electrostatic repulsion.

(6). When the number of electrons in the outside layer is

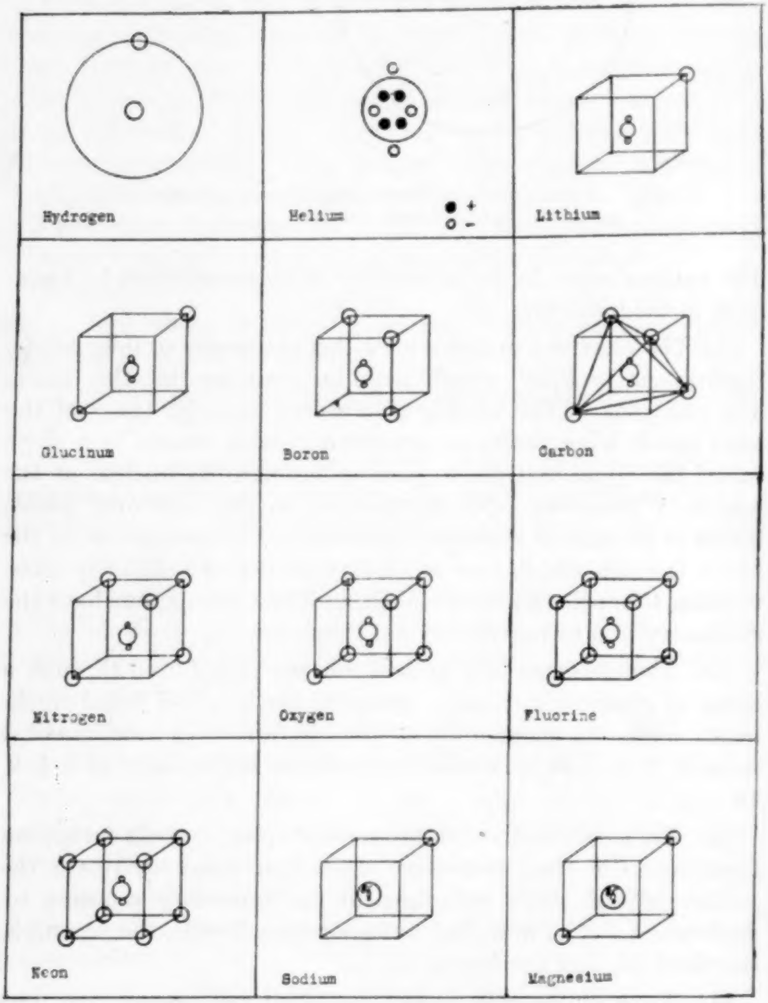

Fig. 5.

The first twelve elements in the periodic system according to the Lewis-Langmuir system. The dimensions are not relative. The nucleus of Helium has been reduced in size and occurs in all subsequent elements, furnishing the inner system of two electrons. The nucleus is indicated and is presumed to have the same general composition as that indicated by the Kossell system.

small, the arrangement of the electrons is determined by the (magnetic?) attraction of the underlying electrons. But when the number of the electrons increases, especially when the layer is nearly complete, the electrostatic repulsion of the underlying electrons and of those in the outside shell becomes predominant.

(7). The properties of the atoms are determined by the number and arrangement of the electrons in the outside layer and the ease with which they are able to revert to more stable forms by giving up or taking up electrons, or by sharing their outside electrons with atoms with which they combine. The tendencies to revert to the forms represented by the atoms of the inert gases are the strongest, but there are a few other forms of higher symmetry such as those corresponding to certain possible forms of nickel, palladium, erbium and platinum atoms toward which atoms have a weaker tendency to revert (by giving up electrons only).

(8). The stable and symmetrical arrangements of electrons corresponding to the inert gases are characterized by strong internal and weak external fields of force. The smaller the atomic number the weaker the external field.

(9). The most stable arrangement of electrons is that of the pair in the helium atom. A stable pair may also be held by: (a) a single hydrogen nucleus; (b) a hydrogen nucleus and the kernel of another atom; (c) two hydrogen nuclei; (d) two atomic kernels (very rare).

(10). The next most stable arrangement of the electrons is the octet, that is, a group of eight electrons like that in the atom of neon. Any atom with atomic number less than twenty, and which has more than three electrons in its outside layer tends to take up enough electrons to complete its octet.

(11). Two octets may hold one, two, or sometimes three pairs of electrons in common. One octet may share one, two, three, or four of its electrons with one, two, three, or four other octets. One or more pairs of electrons in an octet may be shared by the corresponding number of hydrogen nuclei. No electron can be shared by more than two octets.

The term kernel refers to everything inside the shell into which electrons are being taken. Thus with a structure in which the electrons are arranged 2, 8, 3; 2, 8 is the kernel.

Lewis, borrowing several features from the Bohr theory, summarizes his conception of the atom in the following postulates. This he considers to be a reconciliation of the two theories.

(1). First we shall adopt the whole of the Bohr theory in so far as it pertains to a single atom with a single electron. There are no facts in chemistry which are opposed to this part of the theory, and we thus incorporate in the new model (Lewis model) all of the Bohr theory that is strictly quantitative.

(2). In the case of systems containing more than one nucleus or more than one electron, we shall also assume that the electron possesses orbital motion, for such motion seems to be required to account for the phenomenon of magnetism; and each electron in its orbital motion may be regarded as the equivalent of an elementary magnet or magneton. However, in the case of the complex atoms, we shall not assume that an atomic nucleus is necessarily the center or the focus of the orbits.

(3). These orbits may occupy fixed positions with respect to one another and to the nuclei. When we speak of the position of an electron, we shall refer to the position of the orbit as a whole rather than to the position of the electron in the orbit. With this interpretation, we may state that the change of an electron from one position to another is always accompanied by a finite change of energy. When the positions are such that no change in the positions of the several parts of the atom or molecule will set free energy, we may say that the system is in the most stable state.

(4). In a process, which consists merely in the fall of an electron from one position to another more stable position, monochromatic radiant energy is emitted, and the frequency of this radiation multiplied by h, the Planck constant, is equal to the difference in the energy of the system between two states.

(5). The electrons of the atom are arranged about the nucleus in concentric shells. The electrons of the outermost shell are spoken of as valence electrons. The valence shell of a free (uncombined) atom never contains more than eight electrons. The remainder of the atom which contains the nucleus and the inner shells is called the kernel. In the case of the noble gases it is customary to consider that there is no valence shell and that the whole atom is the kernel.

(6). In my paper on "The Atom and the Molecule" I laid much stress upon the phenomenon of the pairing of electrons. I am now convinced that this phenomenon is of greater importance than I then supposed, and that it occurs, not only in the valence shell, but also in the kernel, and even in the interior of the nucleus itself. There is nothing in the known laws of electrical force,

nor is there anything in the quantum theory of atomic structure, as far as it has yet been developed, to account for such pairing. . . .

(7). We may consider a recent idea advanced by Bohr (1921), which is not based so much upon deductions from his atomic model as upon a direct consideration of the experimental data on spectral series. He assumes essentially that the first shell is associated with a single energy level, and that this level can accommodate one pair of electrons, that the second shell contains two energy levels, each of which is capable of holding two pairs of electrons, making a maximum of eight electrons in the second shell. The third shell has three energy levels, each of which can hold three pairs of electrons, so that the maximum number of electrons in the third shell is eighteen. The forth shell comprises four levels, each capable of holding four electron pairs, making a total of thirty-two electrons, and so on. . . .

Lewis, with his ideas regarding the reconciliation of the two views of atomic structure, is apparently adopting the reasonable attitude, namely; endeavoring to take the firmly established postulates of each view and weld them into a substantial and successful theory.

The arrangement of the electrons according to the Lewis-Langmuir theory is illustrated in Fig. 5. It will be noted that there is a similarity in the plan followed here, with that pursued in both the Kossell and Bohr theories, the increment of electrons following in the same order, although their arrangement is different. The atoms in general tend toward stability through the addition or loss or sharing of enough electrons to complete the octet. This completion of the octet generally carries the structure to that of the noble gases. The exceptions to this general tendency are listed under postulate 7 of Langmuir's summation. In most cases this theory deals with the completion of the octet through the sharing of electrons. In the Kossell theory the loss or gain of electrons results in the development of electrostatic charges which are interpreted as valences, one valence bond being considered equivalent to the loss or the gain of one electron. The same thing is substantially true of the Bohr theory with regards to valence although there is a possibility of electron sharing through the overlapping of two orbits of two atoms, with the resulting rotation of the electron pair in an orbit at right angles to the plane occupied by the two orbits. According to the Lewis-Langmuir theory the valence bond is developed by

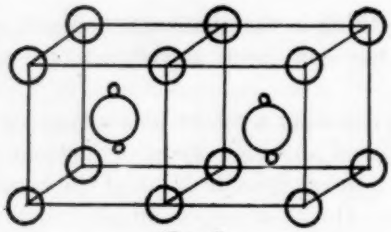

FIG. 6.
An example of a bi-valent union according to the Lewis-Langmuir theory. Oxygen molecule.

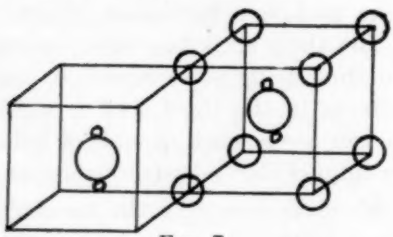

FIG. 7.
An example of a mono-valent union according to the Lewis-Langmuir theory. Lithium fluoride.

the sharing of two electrons, one pair of shared electrons being equivalent to one valence bond. See Fig. 6. A later paper will deal with the subject of valence as developed by the theories outlined here.

The Lewis-Langmuir theory has been accepted in the main through its ability to explain the periodic properties of the elements. That is its primary chemical justification. In addition, it meets with success in explaining magnetic properties, and applies also to the physical properties such as boiling point, freezing point, electrical conductivity, etc. It leads to a simple theory applicable to polar and non-polar compounds. Its ability to explain many perplexing questions of valence in organic compounds, to say nothing of the explanation offered to the unusual compounds of the inorganic series, has shown this theory to be a most important one. Portions of it will, undoubtedly, be modified but much of it will find its way into an accepted atomic structure theory.

CONCLUSION.

The writer realizes that the foregoing is merely a sketch of the vast field covered by each theory considered. He claims no credit for originality in the foregoing, having borrowed freely

from all available sources in the preparation of this brief review of the subject. For the benefit of those who desire more detailed accounts of the subject matter of the theories the following incomplete bibliography is appended. No references were available for the Kossell theory. This will not be a handicap since this theory has lost nearly all of its former significance.

THE BOHR THEORY.

SIDGEWICK—*The Electron Theory of Valency*—Oxford Press.

BERTHOUD—*New Theories of Matter and the Atom*—Macmillan.

KRAMER & HOLTZ—*The Atom and the Bohr Theory of Its Structure*—A. Knopf, New York.

THE LEWIS-LANGMUIR THEORY.

SIDGEWICK—See above.

LEWIS—*Valence and the Structure of Atoms and Molecules*—Chemical Catalog Co.

IRVING LANGMUIR—*The Arrangement of Electrons in Atoms and Molecules*—Jour. Amer. Chem. Soc.—41,868, 1919.

WASHBURN—*Principles of Physical Chemistry*—McGraw Hill.

MOON LIKE VOLCANIC ASH.

Whatever the moon consists of, it is some very porous material similar to volcanic ash on the earth, and not at all like any solid rock of which we know.

This was the announcement made by Dr. Paul S. Epstein, of the California Institute of Technology, using data furnished by measurements of the moon's temperature during a recent lunar eclipse by Dr. S. B. Nicholson and Dr. Edison Pettit, of the Mt. Wilson Observatory.

A mathematical expression of the way the moon cooled when it entered the dark shadow of the earth, and so received no heat from the sun, gave the value of 120. Dr. Epstein made similar measurements in the labortory of the cooling of various materials. Granite gave a value of 16, which meant that it cooled more slowly. Basalt gave 24, and quartz sand 58. Pumice stone, however, gave values of between 100 and 150. As pumice is of volcanic origin, this appears to be new evidence in favor of past volcanic action on the moon, which may have formed the craters.—*Science News-Letter*.

MAGNETISM TESTS METALS.

Magnetism, working silently without injuring metal, is a testing tool coming more and more into industrial and research use, Raymond L. Sanford, chief of the magnetic section of the U. S. Bureau of Standards, told the American Institute.

Case-hardened chain, heat-treated forgings and steam turbine bucket wheels are among the products now given a routine magnetic analysis to detect flaws and insure quality.

In exploring the qualities produced by new steel treatments, in determining the changes that take place during the cooling or heating of a ferrous alloy, magnetic analysis is used by scientists investigating the properties of materials.

Inspection of welds is facilitated by magnetic methods. Since welding is coming into larger industrial use, the magnetic test will facilitate the control of this modern method of joining metals together.—*Science News-Letter*.

STATE NATURAL HISTORY SURVEY AND THE HIGH SCHOOL.

By Dr. S. A. Forbes,
Chief of the State Natural History Survey of Illinois,
AND
P. K. Houdek,
President of Illinois Biology Teachers' Association, and Chairman of Biology Section of the High School Conference.

Having realized, by sad experience, the lack of accessory material for the teaching of biology to be found in most of the high schools of Illinois, we, of the Biology Teachers Association, gladly welcomed the offer of assistance by Dr. Forbes of the State Natural History Survey. The committee co-operating with Dr. Forbes was selected to include a wide variety of schools and situations. The personnel of the committee is as follows: Mr. Jerome Isenbarger, Chairman, 2200 Greenleaf Ave., Chicago, Ill.; Miss B. Eva Hoehn, Carlinville, Ill.; Mr. Worrallo Whitney, 5743 Dorchester Ave., Chicago, Ill.; Mr. M. D. Renkenberger, Township High School, Joliet, Ill.; Mr. V. H. Condon, Township High School, Bloomington, Ill.; Mr. P. K. Houdek, 710 North Cross, Robinson, Ill.

It is hoped to begin the work by the distribution of the available material that has been adjudged suitable by the committee. Very likely some of the present publications will be rewritten and adapted to the new conditions. Later there may be some special preparations. This new departure by the State Natural History Survey is very promising and encouraging to the natural science teachers of the state. The interest already manifested is an indication of the fullest co-operation.

As indicated by Dr. Forbes later in this article we need and are hoping for the advice and suggestions of a great many teachers, supervisors, and principals before we can complete our work. We invite, yes, even solicit, the comments of every progressive biology teacher interested in our attempts. The following paragraphs by Dr. Forbes explain very clearly the stand that the Survey has taken in the matter.

"When, in 1872, I had recently been appointed curator of the only general museum of natural history then belonging to the state, I was profoundly interested in the fact that teaching of the natural sciences had just been made by law the duty of the public schools of Illinois, and competency to teach them had been suddenly required as a prerequisite for either a state or

county certificate, except that teachers otherwise qualified might receive a provisional certificate good for only one year and valid only in the district for which the teacher was engaged. An immediate and general demand for means of preparation for the new duties naturally appealed strongly to the new curator and led to the preparation of a series of papers on the natural history subjects and their teaching which were published in the 'Chicago Schoolmaster,' 1872, and the 'Illinois Schoolmaster,' 1873, 1874, 1875 and 1876. There was also organized in 1873 a 'School and College Association of Natural History,' the object of which was to stimulate and assist the collection and determination of specimens of plant and animal life by teachers and pupils and to supply additional material to the schools by a distribution of duplicates from the young museum; and sessions of a special summer school for teachers of zoology and botany were held in 1875 and 1876. This impulse to educational service survived the emergency which gave it birth and when the 'Illinois Museum of Natural History,' which had become in 1877 the State Laboratory of Natural History, was established at what is now the University of Illinois, its fundamental law required that in its comprehensive survey of the zoology and botany of the state it should give preference to subjects of educational and economic importance, a requirement which was continued in force when in 1917, this laboratory became the present Natural History Survey Division of the State Department of Registration and Education. During this period of 57 years of very slow but steady growth it has published 17 volumes of its Bulletin, 18 biennial reports of the State Entomologist, two volumes on the ornithology of the state, and a volume and atlas on its fishes, besides a considerable number of miscellaneous pamphlets on various special subjects, a total of 14,400 pages on the biology of Illinois, illustrated by hundreds of text figures, 916 full-page plates, and 212 maps.

"These publications were freely but judiciously distributed throughout the state as fast as they were issued from the press and many of the earlier numbers are now out of print but several even of these have been reprinted when the demand for them continued and the supply of those still wanting can be replenished as necessary, sometimes with improvements made by the incorporation of fresh materials or by revision with a view to a better adaptation to special ends. It is by opening up to high school teachers this mine of contributions to the biology of

Illinois, reshaping them where necessary to the teachers' end, that the Natural History Survey is now undertaking to establish closer relations with the public schools than the indefinite and miscellaneous contacts of recent years—relations which it is hoped may become more varied and more important in many ways than ever before and may help especially to stimulate the interests and enrich the experience of the youths and maidens of the state in the native life of the woods and waters, the fields and parks and gardens of their neighborhoods. But our hope to cooperate with the high school teacher does not stop with these merely elementary interests. The eighteen of us who are associated in the operation of the Natural History Survey (there was but one fifty years ago) are all engaged in biological research and would like to convey to the high school student, and perhaps the teacher also, some interesting and fruitful knowledge of the uses of the scientific method by which our results have been attained. With these general objects in view, we asked for conference and cooperation from the biology section of the high school conference, before which I read a paper at its last meeting on the topic, 'What Can the Natural History Survey Do for the High School?' and a carefully selected committee from the Illinois Biology Teachers' Association was appointed to whose members we have submitted a collection of our most promising publications for their judgment of the utility of these papers as accessory material in the teaching of high school biology. Upon the receipt of their replies copies of approved bulletins will be distributed to high schools according to some plan not yet discussed by us and measures will be taken for the republication of certain articles requiring revision and, as experience and conference make us intelligent, for the preparation of booklets of kinds particularly needed.

"In order that we may make our contribution as directly and completely useful as possible, we hope to have the benefit of the experience, the reflections, the advice, and the active assistance of not only the high school visitors, whose office is of course quite open to us, but especially that of the high school principals and high school teachers of biology."

MEASURES SPEED OF BIRDS.

Prof. Thienemann of Rossitten, East Prussia, gives the following as the established speeds of certain birds during migration: The sparrow develops a speed of 25 miles per hour; the gray gull, the black-back gull and the Norway crow have the same speed, 31 miles per hour. The rook and the finches reach 32 miles per hour. The speediest flier is the starling, with approximately 45 miles per hour.—*Science News-Letter.*

RELATION BETWEEN SIMPLE INTEREST AND COMPOUND INTEREST.

By M. O. Tripp,
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There are numerous interesting relations connecting simple and compound interest. The time that it takes a sum of money to double at simple interest is not of much importance, since business is usually carried out on the basis of compound interest, that is, business firms are generally managed in such a way that any interest due is collected or put into new interest-bearing funds. In fact, compound interest is, in many respects, of much more importance than simple interest.

The time required for a sum of money to double at compound interest can be found approximately by the following rule: Divide .70 by the rate per period; the quotient will be the number of periods. Thus at 5 per cent per year money doubles in fourteen years. At 6 per cent per year compounded semi-annually we find $.70 \div .03 = 23$ half years, approximately, that is, eleven and one-half years. This is an easy rule to remember and can be applied mentally.

The more frequently interest is compounded the greater the income on a given capital. For example, interest compounded quarterly, as is common on corporation stocks, brings in a larger annual income than is usually imagined. For example, interest at 6 per cent converted quarterly is equivalent to a yearly rate of interest at about $6\frac{1}{7}$ per cent. The present tendency of some public utility companies increases the rate still more. Thus, a monthly dividend on 6 per cent stock is the equivalent of yearly rate of about $6\frac{1}{6}$ per cent.

When a grocer buys sugar and sells out his supply in a short time, reinvesting the money at once, the compound interest principle is really put in operation, and this is one reason why he can sell at a small profit. On the other hand a prescription druggist who keeps his drugs a long time before converting them into money must charge a larger profit, because the compound interest principle is not operating so rapidly. Naturally there are other factors entering into the question of profits, but the principle of conversion of interest on money is an important one.

The teaching of interest in our public schools does not lay sufficient stress upon compound interest. The claim is made

that this subject is not practical; but a careful study shows that the principle of conversion of interest is decidedly important.

In business it is common to figure simple interest whenever it is a question of getting interest for a period less than the period of conversion. For example, if we wish to get the compound amount of a sum of money P for five years and six months at six per cent compounded annually, in ordinary commercial relations, we would write, if S is the compound amount,

$$S=P(1+.06)^5\,(1+.03).$$

This amount S is somewhat different from the amount

$$S'=P(1+.06)^{\frac{11}{2}},$$

although the latter amount expresses more exactly the general idea of compound amount.

We now define compound amount by the formula

$$A=P(1+r)^k$$

where A = amount, P = principal, r = rate per period, k = number of periods.

The formula for the simple amount is

$$A'=P(1+kr).$$

We now propose to show that

$$A<A' \text{ when } o<k<1 \text{ and } o<r<1,$$

that is, the compound amount is less than the simple amount for any period less than the interval of conversion.

By the binominal theorem we have

$$(1+r)^k=1+kr+\frac{k(k-1)r^2}{2!}+\frac{k(k-1)\,(k-2)r^3}{3!}$$
$$+\frac{k(k-1)\,(k-2)\,(k-3)r^4}{4!}+\ldots\ldots \qquad \text{I}$$

We now group the terms by twos, starting with the 3rd, in such a way that each group shall be a negative number. Thus, taking the 3rd and 4th terms, we have

$$\frac{k(k-1)r^2}{2!}+\frac{k(k-1)\,(k-2)r^3}{3!}=\frac{k(k-1)r^2}{2!}\left\{1+\left(\frac{k-2}{3}\right)r\right\} \qquad \text{II}$$

The factor on the right in front of the brace is negative. The binomial in the brace is positive, accordingly the sum of the 3rd and 4th terms is negative. Again taking the sum of the 5th and 6th terms in I,

$$\frac{k(k-1)\,(k-2)\,(k-3)r^4}{4!}+\frac{k(k-1)\,(k-2)\,(k-3)\,(k-4)r^5}{5!}=$$
$$\frac{k(k-1)\,(k-2)\,(k-3)r^4}{4!}\left\{1+\left(\frac{k-4}{5}\right)r\right\} \qquad \text{III}$$

Evidently the factor in front of the brace is negative, and just as before the binomial in the brace is positive. Hence the sum of the 5th and 6th terms is negative. Clearly this process can be continued as far as we please; and since the binomial series I is convergent, the sum of all the terms beginning with the 3rd is negative.

Hence we have

$$A < A'.$$

Another theorem that is usually assumed as obvious can be proven analytically in a manner similar to the above. It is this:

$$\text{If } k > 1 \text{ then } A > A'.$$

For integral values of k the theorem is evident, since the first two terms of the binomial expansion give $1+kr$, and the remaining terms are positive.

If $1 < k < 2$, then in II above the factor in front of the brace is positive, and the binomial in the brace is positive also. Therefore the sum of the 3rd and 4th terms is positive. Exactly the same relations will hold for the sum of the 5th and 6th terms from III; and in fact for all succeeding pairs of terms. Hence

$$A > A'.$$

If $2 < k < 3$, then the first three terms in I are positive. The sum of the 4th and 5th terms in I can be put in the form

$$\frac{k(k-1)(k-2)r^3}{3!}\left\{1+\left(\frac{k-3}{4}\right)r\right\}.$$

The factor in front of the brace is positive and the binomial in the brace is also positive. The same results hold for the sum of the 6th and 7th terms, and so on in pairs. Therefore the theorem holds in this case.

If $3 < k < 4$, the sum of the first four terms of I is positive; and, as in the preceding case the sum of the 5th and 6th terms is positive, and so on.

The method can thus be extended to the case of k lying between any two consecutive positive integers, and therefore the theorem is true in general.

It should be observed that for $k = 1$

$$A = A',$$

that is, the compound amount for a single period of conversion is the same as the simple amount.

RECENT DISCOVERIES CONCERNING THE INTERACTION OF LIGHT AND MATTER.

By J. Rud Nielsen,
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The new scattering effect discovered a few months ago by Professor C. V. Raman and K. S. Krishnan[1] of Calcutta, India, is undoubtedly one of the greatest scientific discoveries made in recent years. Not only is it of the utmost importance for Theoretical Physics, but it promises to give us a very valuable method for the study of molecular structure. It is, therefore, of equal interest to physicists and chemists.

Some knowledge of modern physics is necessary for the understanding of this new phenomenon. In the present article we shall review briefly, and in the simplest possible language, our present conceptions of the structure of atoms and molecules and of the interaction of light and matter. In a second article, the Raman effect—as the new effect has been named—will be treated somewhat in detail.

Atomic and Molecular Structure.[2]

An atom is built up of an equal number of protons, or units of positive electricity, and electrons, or units of negative electricity. According to Rutherford, all the protons and a number of the electrons are united in the so-called nucleus. The nucleus is exceedingly small and, since the mass of a proton is almost two thousand times as great as the mass of an electron, contains almost the entire mass of the atom. The remaining electrons revolve around the nucleus with tremendous speeds and at distances from it which are very large compared with the diameter of the nucleus. The motions of these electrons do not obey the ordinary laws of mechanics and electrodynamics, and we have no means of studying them in detail. However, the Bohr theory and the more recent Matrix Mechanics, developed by Heisenberg, Born, Dirac, and others, permit us, at least in simple cases, to derive certain important properties of the atoms.

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[1]Indian Journal of Physics 2, III, 1, 1928; 2, IV, 399, 1928; Nature, Vol. 121, 501, 619, 711, 1928; Vol. 122, 650, 1928.

[2]Of the many reference works on this subject the following are recommended:

(a) *Popular:* Kramers and Holst, The Atom and the Bohr Theory of its Structure, English Translation, Gyldendal, Copenhagen 1923. Bertrand Russell, The A B C of Atoms, Dutton, London 1923.

(b) *Semi-popular:* K. K. Darrow, Introduction to Contemporary Physics, Van Nostrand, New York 1926.

(c) *Technical:* A. Sommerfeld, Atomic Structure and Spectral Lines, English Translation, Methuen, London 1923. E. N. da C. Andrade, the Structure of the Atom, 3rd Edition, Harcourt, Brace and Co., New York 1926. G. Birtwistle, The New Quantum Mechanics, Cambridge University Press, Cambridge 1928.

Both theories assume that the energy of an atom or molecule cannot vary continuously but is limited to a discrete set of values. This is known from experiments, such as those carried out by Franck and Hertz and others, in which a stream of electrons, coming from a hot filament, is sent into a gas or vapor, the speed of the electrons being varied by varying the grid voltage. When the speed of the electrons is sufficiently small, the electrons are simply scattered in all directions by the atoms of the gas. The collisions between electrons and atoms are as between elastic balls. The loss of kinetic energy suffered by an electron in a collision depends upon the angle it is deflected, but will in all cases be very small due to the smallness of the mass of an electron as compared to that of an atom.

When the speed of the electrons sent into the gas has reached a certain value, depending on the gas used, most of the collisions become *inelastic* and result in the transfer of the entire kinetic energy of the electron to the atom. A small increase in the speed beyond this value does not alter the amount of energy transferred, but simply leaves the electrons with a part of their kinetic energy after the collisions.

If the speed of the electrons is further increased, a second characteristic speed is reached for which a collision with an atom may again result in a transfer of the entire kinetic energy of an electron to the atom. A further increase in speed will not change the amount of energy transferred until a third critical speed is reached, and so on. These experiments show, in the most direct manner, that the atomic energy is limited to a definite set of values characteristic of the element. The kinetic energy which an atom may have due to a translatory motion is not here taken into consideration, for this energy is, generally, very small compared with the energies transferred in the experiments described.

At ordinary temperatures practically all the atoms are in the "normal" state, i. e. they have the lowest possible energy value. An atom which has acquired a greater energy, by electron impact or otherwise, is said to be "excited." In an excited atom one or more of the electrons move in orbits farther away from the nucleus than in the normal state.

If a colliding electron has a speed exceeding a certain high value characteristic of the gas, the collision may result in the complete removal of an electron from the atom; the atom is "ionized." If it should happen that the electron collides with an

excited atom, the atom may impart its excess energy to it. The electron is then speeded up, while the atom returns to its normal state. Such collisions, which were first considered by O. Klein and S. Rosseland, are said to be of the "second kind." A collision of the second kind may also occur between an excited atom and another atom.

While the experiments on the collisions between electrons and atoms have given very direct evidence of the discrete energy values of atoms, these experiments do not lead to accurate measurements of the energy values. Fortunately, however, we have another method which is exceedingly precise. When an atom is excited, it will, generally within less than a ten-millionth of a second, give up spontaneously all or part of its excess energy in form of electromagnetic radiation or light. According to Bohr's frequency relation, the frequency ν of the light emitted is always equal to the difference between two energy values, say E' and E'', divided by Planck's universal constant, $h = 6.55 \times 10^{-27}$ erg$\times$sec.; or

$$h\nu = E' - E'' \qquad (1)$$

In Spectroscopy the wave-lengths λ emitted by the various chemical elements are measured with an accuracy unsurpassed in any other scientific measurements. After the frequencies have been computed from the formula $\nu = c/\lambda$, where c is the velocity of light, Bohr's frequency relation, together with several more special laws, is employed to determine the energy values of the atoms. For elements with simple spectra, such as the alkali metals, practically all the energy values are very accurately known. For elements with complex spectra, e. g. neon, iron, titanium, etc., a very large number of energy values is already known, and our knowledge of the energy values is being rapidly extended.

Molecules have a more complicated structure than atoms. They contain two or more atomic nuclei separated by considerable distances. Most of the extra-nucleur electrons revolve around a nucleus in much the same way as in the atom. However, in a sodium chloride molecule, for example, one of the electrons, originally belonging to the sodium atom, revolves around the chlorine nucleus. The molecule, therefore, acts as an electric dipole and is said to be polar, while molecules with negligible electric moment, like N_2, CO or NaK, are said to be non-polar. In non-polar molecules some of the outermost electrons may revolve around more than one nucleus.

The energy of a molecule, just like that of an atom, cannot vary continuously but is limited to a set of discrete values. The spacing of the energy values, however, is quite different in the two cases, as is indicated schematically in Fig. 1. Here each horizontal line represents an energy value. The lowest line represents the lowest or normal energy value of the atom or molecule. The other lines are drawn so that their distances from the lowest line are proportional to the excess energy in the various excited states. In an atom the smallest excess energy is, generally, very considerable; in fact, all of the lower energy values are widely spaced. The excess energy, in the case of an atom, is due to the displacement of one or more electrons to orbits farther from the nucleus. Molecules possess, in addition to this so-called electronic energy, energy associated with the approximately harmonic vibrations of the nuclei about their equilibrium positions and also energy due to the rotation of the molecule as a whole. The rotational energy values lie very close together. Also the values of the vibrational energy, while somewhat more widely spaced, are not nearly as far apart as the electronic energy values.

FIG. 1. SCHEMATIC REPRESENTATION OF THE LOWER ENERGY VALUES FOR ATOMS AND MOLECULES.

It follows from Bohr's frequency relation, which applies to molecules as well as to atoms, that molecular spectra contain a very large number of frequencies, some of which differ by very small amounts. From their appearance when viewed in a spectroscope, molecular spectra are called *band spectra*, while spectra emitted by atoms are called *line spectra*. If only the rotational energy of a molecule changes, we get the so-called pure rotation bands, which, generally, lie in the far infra-red region of the spectrum. If also the vibrational energy changes, we get the vibration-rotation bands in the near infra-red. Finally, if a change in the electronic energy is also involved, we get the so-called electronic bands, generally lying in the visible or ultraviolet part of the spectrum. Our knowledge of the energy values of molecules is derived almost entirely from the analysis of their spectra.

Interaction of Light and Matter.

Emission and Structure of Light.—Light has its origin in excited atoms or molecules. Its emission is associated with the passage of the atom or molecule from a higher to a lower energy value and its frequency is determined by Bohr's frequency relation (Eq. 1). The theories mentioned at the beginning of this article permit us, in simple cases, to determine the polarisation of the light as well as the frequencies and relative intensities of the various spectral lines. However, we cannot yet give a detailed description of the emission process. This is partly due to our ignorance about the structure of light. It is well known that the experiments on the interference and diffraction of light compel us to regard light as a wave-phenomenon. This view is strongly supported by the electromagnetic theory of light which has received conclusive experimental verification. However, the photo-electric effect and other phenomena connected with the interaction of light and matter force us equally strongly to consider light as a stream of particles. The creation of a theory, comprehensive enough to embrace both of these seemingly contradictory aspects of the structure of light, is one of the most important problems confronting Physical Science.

This duality or complementarity in our ideas of the structure of light has been made somewhat more acceptable by a remarkable discovery, made recently by Davisson and Germer[3] of the Bell Telephone Laboratories. They found that the scattering of electrons by a crystal exhibits interference phenomena analogous to those obtained in the scattering of X-rays. Electrons, therefore, have something in common with waves and may be regarded as "wave parcels," a view first advocated by L. de Broglie on theoretical grounds.

Absorption Phenomena.—We shall now consider a group of phenomena which depend on the absorption of the light by an atom or molecule. Let the atom or molecule have the lowest energy value E_o, and let the frequency ν of the light be such as to satisfy the relation $h\nu = E_m - E_o$, where E_m is the energy value of the atom or molecule in the m'th excited state. The atom or molecule may then absorb the amount $h\nu$ of the energy of the light, thereby passing from the normal state to the m'th excited state. Hence the absorption process is the reversal of the emission process and is equally obscure.

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[3]A semi-popular account of this work is given by Dr. C. J. Davisson in the Journal of the Franklin Institute, Vol. 206, 597, May, 1928.

An atom or molecule after being excited by the absorption of light will, in general, remain in the excited state only for a very short time, say a hundred-millionth of a second, after which the excess energy is emitted in form of light. It may be said that a hundred-millionth of a second, while small in our measure, is a very long time for the atom, for in this time its electrons will have performed millions of revolutions. If the transition of the atom to its normal state takes place directly, the emitted light will have the same frequency as the incident light. On the other hand, if a step-wise transition occurs, the atom lingering for short intervals of time in the intermediate energy states, light of several frequencies will be emitted, all of which frequencies are smaller than the frequencies of the incident light. This emission of light, produced by optical excitation, is called *fluorescence.* The fact that the frequencies of the fluorescence radiation cannot exceed the frequency of the incident light is called, after its discoverer, Stokes' Law. It is clear that if the atom were in an excited state before the absorption, the fluorescence light might be of greater frequency than the incident light.

The incident light will not be absorbed by a monatomic gas unless its frequency very accurately satisfies the relation $h\nu = E_m - E_o$, while molecules, with their closely spaced energy values, may absorb the light and fluoresce whenever ν is above a certain value or lies in certain frequency intervals. The frequencies of the fluorescence radiation are always characteristic of the atom or molecule emitting it. A change in the frequency of the incident light produces no change in the frequencies of the fluorescence light but alters only its intensity.

If the incident light has a frequency ν so large that the product $h\nu$ is larger than the energy P needed for the complete removal of an electron from an atom, the light may, so to speak, knock an electron out of the atom. This phenomenon is called the *photo-electric effect.* It is rather difficult to observe in gases but is easily observed with solids or liquids. As predicted in 1905 by Einstein, and much later verified experimentally by Millikan, an amount $h\nu$ of light energy may be transferred onto a single electron which will escape from the atom with a kinetic energy equal to $h\nu - P$. The fact that the kinetic energy of the escaping electrons depends only on the frequency of the light and not at all upon its intensity strongly suggests that light consists of particles or "quanta" each having the energy $h\nu$. If fact, unless this assumption is made, the photo-electric effect remains quite unintelligible.

Since the chemical behavior of excited atoms or molecules is often quite different from the behavior of the atoms or molecules in their normal energy state, the absorption of light is often accompanied by chemical reactions. These so-called *photochemical reactions* present many features which are not yet well understood. However, the evidence derived from them also seems to favor the theory of light quanta.

Scattering Phenomena.—The scattering of light in all directions by dust particles in air or by a colloidal solution is a well known phenomenon which was extensively studied by Tyndall and is named after him. Pure liquids and gases, as well as transparent solids, scatter light to a very much smaller degree. If monochromatic light is used for illumination, the scattered light is seen to have the same color or wave-length as the incident light. However, if the incident light is white, the scattered light will, generally, have a bluish color, since the blue light is scattered very much more strongly than the red light. This accounts for the blue color of the sky, as was shown by Lord Rayleigh. In fact, if there were no scattering of light in the atmosphere, the sky would be perfectly black, and the sun would appear unbearably bright.

The scattered radiation is superposed on the incident radiation and gives rise to the so-called *dispersion* of the light, i. e., to the dependence of the index of refraction upon the wave-length. The scattered light is *coherent* with the incident light, i. e., there is a constant phase difference between the incident and the scattered light. As a consequence, the light scattered from different molecules or atoms will interfere. If the atoms or molecules are regularly arranged, the scattered light will almost completely destroy itself by interference before getting out of the medium in which it is produced. The fact that a part of the scattered light does get out of the medium is due to slight irregularities in the arrangement of the molecules or fluctuations in the density of the medium. The density fluctuations become very large when a gas is brought to its critical state, and the scattering is consequently enormously increased.

The scattering of X-rays is in some respects different from the scattering of ordinary light and has, perhaps, been more thoroughly investigated. A very remarkable phenomenon was discovered a few years ago by Professor A. H. Compton[4], of the

[4]See e.g. A. H. Compton, X-rays and Electrons, Van Nostrand, New York, 1926.

University of Chicago. He found that when X-rays of wave-length λ are scattered by materials of small density, the scattered rays contain, besides the wave-length λ, a slightly larger wave-length $\lambda + \triangle\lambda$. The change in wave-length $\triangle\lambda$ is independent of the scattering material but depends on the angle of scattering. Compton, and also Debye, gave the following simple explanation of this phenomenon, based on the theory of light quanta. A light quantum of energy $h\nu$ must, according to Einstein's law of the equivalence of mass and energy, have a mass $\frac{h\nu}{c^2}$, and, since c is the velocity of the light, a momentum $\frac{h\nu}{c}$. If a light quantum collides with one of the outermost electrons in an atom, it may knock this electron out of the atom. The light quantum will then be deflected and lose part of its energy. A decrease in the energy of the light quantum means a decrease in frequency or an increase in wave-length. If it be assumed that the scattering electron is so loosely bound that the light quantum produces no effect upon the rest of the atom, the electron may be treated as free, and the laws of the conservation of energy and momentum suffice to determine the change in wave-length $\triangle\lambda$ corresponding to a given angle of deflection θ. It is found that

$$\triangle\lambda = \frac{2h}{mc}\sin^2\frac{\theta}{2}, \qquad (2)$$

where m is the mass of an electron, h Planck's constant, and c the velocity of light. Substituting $h = 6.545 \times 10^{-27}$ erg$\times$sec, $m = 9.043 \times 10^{-28}$g, $c = 2.998 \times 10^{10}$ cm/sec we get, for $\theta = 90°$, $\triangle\lambda = 0.0242 \times 10^{-8}$ cm.

Light is also scattered by the electrons in the atom which are too firmly bound by the nucleus to be disrupted. The light quantum then acts upon the atom as a whole, and, due to the large mass of the atom, the wave-length change will be too small to be observed. When the scattered X-rays are resolved by the aid of a spectrograph we get, therefore, an unmodified as well as a modified line. The denser the scattering material and the lower the frequency of the X-rays, the greater the relative intensity of the unmodified line. The *Compton effect* is not observed with ordinary light because its frequency, or the energy of its quanta, is too small to remove even one of the most loosely bound electrons, at least without complete absorption of the light.

The discovery of the Compton effect has greatly strengthened

the theory of light particles or quanta. In fact, the action of light upon atoms or molecules appears very similar to that of impinging electrons. Atoms may be excited and ionized as well by illumination as by electron bombardment. The scattering phenomena so far considered correspond exactly to elastic collisions of electrons with atoms or molecules or other electrons.

Immediately after Compton's discovery, W. Duane and G. L. Clark, of Harvard University, experimenting on the scattering of X-rays by materials of low density, observed an effect which they termed the "tertiary radiation." Compton showed that this radiation can be explained as consisting of scattered light quanta each one of which has expelled one of the innermost or "K"-electrons from the atom and has given it an additional kinetic energy. The remainder of the energy of the light quantum, and, therefore, its frequency, varies according to the amount of kinetic energy imparted to the electron.

A few months ago B. Davis and D. P. Mitchell[5], of Columbia University, reported somewhat similar observations. They employed an X-ray spectrometer of high resolving power in a study of the radiation scattered by graphite, and found three modified frequencies. One of these seems to belong to scattered light quanta which have extracted an innermost electron from the carbon atom without giving it any appreciable kinetic energy. The other modified frequencies probably belong to light quanta which have removed a less firmly bound electron from the atom and continue their path in an altered direction and with diminished frequency.

The recent discovery of Raman and Krishnan extends greatly the analogy between the action of light and of electrons upon atoms or molecules and furnishes a new support for the corpuscular theory of light. An impinging electron may, as we have seen, excite an atom and move on with reduced kinetic energy. Similarly, we might expect a light quantum, of sufficient energy $h\nu$, to be capable of exciting an atom or molecule, and thereafter moving on with a diminished energy $h\nu' = h\nu - (E_m - E_o)$, where $E_m - E_o$ is the excess energy imparted to the atom or molecule. Now, as we have seen, $E_m - E_o = h\nu_i$, where ν_i is one of the frequencies absorbed by the atom or molecule. Hence the light quantum, scattered in this manner, would have a modi-

[5]A brief but excellent account of this discovery, as well as of that made by Duane and Clark, is given by K. K. Darrow, in *Science*, Vol. 68, 488, November 16, 1928. A bibliography will be found there.

fied frequency $\nu' = \nu - \nu_i$. If the atom or molecule had been in an excited state to begin with, the collision with the light quantum might be analogous to an electronic collision of the second kind, resulting in the transfer of the excess energy to the light quantum, thus giving a frequency $\nu + \nu_i$.

The prediction of modified frequencies $\nu \pm \nu_i$ in the scattered light is supported, as we shall see in the next article, by more elaborate theories. In the discovery of the Raman effect this prediction has received a distinct verification.

TIDES SLOW EARTH.

One and a half billion horsepower, the rate at which the tides of the earth expend their energy, are responsible for a slowing of the earth's rotation somewhat less than a thousandth of a second every century. This was the announcement made by Walter D. Lambert, of the U. S. Coast and Geodetic Survey.

The usual conception of the tides causing friction, and so slowing down the earth as the friction of a brakeband slows down a moving wheel is not correct, Mr. Lambert pointed out. It is simply a matter of the dissipation of energy, he said. The earth has a certain amount of energy by virtue of its rotation and mass, and this is given up to be dissipated by the tides.

Mr. Lambert criticised some of the current geological notions. "Geologists say that in past geologic eras there were great areas of shallow seas," he said, "and these would be favorable, as such, to large tidal friction and to a more rapid rate of change in the length of the day with perhaps attendant geologic consequences of interest. But shallow seas alone are not enough to produce tidal friction. There must be oceans alongside capable of producing large tides to sweep across the shallow seas and thus generate tidal friction and dissipate energy."—*Science News-Letter.*

WILL PISA'S LEANING TOWER EVER FALL?

In spite of the important place Pisa has held in history and in art, many tourists visit it chiefly to view its famous leaning tower. Rumors have got about that this tower is slowly sinking at the base, and that some day it may fall—when Pisa will take one more step down from the proud place she once held.

Apparently the tower was not intended to lean when built. Some fault of the base caused the leaning it is supposed. Thus the world has been marveling for years at the Leaning Tower of Pisa, as it is called.

Yet it is not the only leaning tower. "The most celebrated leaning tower is that of Pisa, which is the campanile of the Cathedral, being 13 feet out of the perpendicular in a height of 179 feet. Two at Bologna, three at Venice, and one at Zaragoza have a still greater inclination." (Webster's New International Dictionary.)

A campanile is a bell tower, especially if it is built apart from the church to which it belongs. The leaning tower of Pisa contains several bells none of which, however, have been rung for many years, lest the vibration cause damage to the tower on its unsteady foundation. The word campanile comes from the Italian "campana," a bell.

ON SEVERAL POINTS IN THE HISTORY OF ALGEBRA.

By G. A. Miller,

University of Illinois, Urbana, Ill.

Near the close of the recent College Algebra by N. J. Lennes, there appears a historical sketch of about 33 pages which many teachers of this subject will doubtless read with much interest and profit. As the author gives explicit references to the works from which he gathered material for this sketch it may be assumed that he himself is not definitely committed to all the views expressed therein and would welcome further discussion of some of the points to which he could refer only briefly but on which widely different views have been expressed by various writers. In the study of such historical questions one is naturally more interested in the arguments on which conclusions have been based than in a statement of some of these conclusions since a study of the former tends to independence of thought and to the formation of a background for further progress along similar lines.

On page 256 of this sketch there appears the following sentence: "It was not until late in Greek history that fractions came to be regarded as numbers." There are few questions in the history of elementary mathematics which are more fundamental and more difficult than the one relating to the use of fractions as actual numbers. Even now we sometimes think of a fraction as the quotient of two integers instead of as a simple number which has a definite place in our common number system. On the other hand, since rational fractions constitute the earliest known extension of our number concept beyond the natural numbers one is naturally very much interested in determining, if possible, when this extension was actually made and by what people.

In considering the question when 0 and negative numbers were first used as actual numbers, considerable stress has been laid on the use of these numbers in the solution of numerical equations since such a use might be assumed to imply that they were regarded as numbers by those employing them in this way. A similar criterion as regards rational fractions would tend to show that they were regarded as numbers by the ancient Egyptians since such fractions appear as solutions of linear equations in the well known work by Ahmes. Moreover, the ancient Egyptians used special symbols for certain fractions, such as $\frac{1}{2}$ and $\frac{2}{3}$. This implies that these fractions were fre-

quently used by them and this use would naturally lead to the view that they are actual numbers, at least on the part of some of those who used these symbols frequently.

It is well known that ancient Greek writers restricted the number concept to the natural numbers but this does not imply that in so doing they were actuated by the views of their mathematical predecessors. It is reasonable to assume that these predecessors had gradually acquired views along this line which they failed to scrutinize, and that the more philosophically minded Greeks were led to adopt views as regards the number concept which were not entirely consistent with earlier ones and which they themselves gradually abandoned in later times. At any rate, these considerations may serve to exhibit some of the difficulties involved in the statement quoted above and to show why one might reasonably expect differences of opinions relating thereto and might desire sufficient data to form an independent opinion.

The decision of the ancient Greeks to restrict the number concept to the natural numbers is somewhat similar to some recent developments, due especially to L. Kronecker, relating to modular systems in which an effort was made to base pure mathematics entirely on the concept of natural numbers. These developments tend to show that while the ancient Greeks did not happen to pursue the best course in this particular instance, they adopted a course which is not lacking in fundamental theoretical advantages, as may be seen also from the following remark, due to Kronecker: "God made integers, all else is the work of man." *Jahresbericht der Deutschen Mathematiker-Vereinigung*, volume 2 (1893), page 19. It is thus seen that even in the nineteenth century there were those who did not adopt the doctrine that all rational numbers are members of a number republic with equal claims on our attention.

In view of the emphasis on the reciprocals of positive integers (unit fractions) in the work of Ahmes one might be inclined to think that these unit fractions were regarded as numbers before the general rational fractions were accorded such recognition. These fractions may be regarded as simply representing measures with regard to smaller units of measure and the oldest known definitions of fractions imply this subdivision of the unit. According to Tropfke's *Geschichte der Elementar-Mathematik*, volume 1 (1921), page 128, the view that the rational fraction is an aliquot part of the numerator, and thus makes the division of

integers by integers always possible, does not appear in the literature before the twelfth century. According to the former of these views, a fraction like 3/4 implies that the unit is divided into four equal parts and three of these parts are represented by this fraction, while according to the latter this fraction is one part when the number 3 is divided into four equal parts. The unit fraction represents only one part according to both of these views, and this may account for the emphasis it has received in the early development of the concept of fractions and the tenacity with which unit fractions were used by later writers.

The generalization of the number concept from positive integers to the positive rational numbers is a very natural one and it is apt to grow up in our minds long before we are interested in a discussion of its justification. It seems therefore natural to assume that this generalization was implicitly used by the early peoples long before the ancient Greeks introduced the view that the ratio of two line segments cannot always be represented by a number even in the case when these segments are commensurable. The fact that our textbooks commonly define a rational number as one which can be expressed as the quotient of two integers shows how readily we now pass from the concept of the division of two numbers to that of representing the result of this operation by a single number. While this transition is of fundamental importance in the development of our subject it does not seem likely that its history can ever be traced very definitely. At any rate, some of the obstacles relating thereto should be of interest to the student of the history of our subject and their study tends to enhance mathematical insight.

A second quotation from the same source appears on page 270 and is as follows: "By the end of the fourth century of our era the complete system of what we call 'Arabic numerals' was in common use among the learned Brahmans. Computing was done by them by means of these numerals; they did not use the abacus." This quotation relates also to a question which is of perennial interest to teachers of mathematics in view of the changing views relating thereto and the interest which students often manifest in the origin of our common number symbols. Hence teachers naturally desire to know the most recent developments which throw light on the perplexing questions to whom we are indebted for our marvelously useful numerical notation and at what time this notation began to be used. Notwithstanding the fact that these questions have received much atten-

tion we possess as yet very little definite knowledge relating thereto and some recent discoveries seem to be in disaccord with the theories which were commonly accepted several years ago.

J. Tropfke, the author of the favorably known history of elementary mathematics to which we referred above, recently published an article in the *Zeitschrift für Mathematischen und Naturwissenschaftlichen Unterricht aller Schulgattungen*, 1928, page 193, in which he states that the oldest known instance of a number written in the positional form, with digits, appeared in Egypt, 873, and exhibits a mixture of the forms used by the eastern and the western Arabs. The latter form spread later in Spain and became the prototype of our common number symbols, but this form appeared also later in Persia. The oldest manuscript which contains the prototype of our modern number symbols originated in a Spanish cloister in 976.

A statement of this article which is of still more interest in connection with the quotation under consideration relates to the possible Greek origin of our positional number system with the nine digits and zero. J. Tropfke directs attention here to our very limited knowledge relating to the mathematical developments during the period from the third to the tenth century of our era, and remarks that the investigator is compelled to feel that what has been credited to the Hindus, the Persians, and the Arabs is mythical, and what was really accomplished in this period had its origin in the Greek intellect. He includes explicitly among these accomplishments the development of our common positional number system with its nine digits and zero, but adds that these matters of feeling as regards the credit due to the Greeks cannot as yet be proved scientifically. It seems possible that the Hindus were indebted to the Persians for their method of representing numbers, and hence our common number system may possibly be traceable through Persia to Greece.

Enough may have been said to show that the quotation under consideration relates to very difficult historical questions on which a great variety of views have been expressed. The modern critical investigator of the history of elementary mathematics naturally finds many evidences which seem to be in disaccord with some of the theories advanced by the earlier writers on this subject. While these evidences are not always sufficient to replace the older theories by others which seem free from objections they present interesting questions for consideration and tend to throw light on some of the difficulties involved in formu-

lating general statements relating to the history of mathematics. This is especially true as regards some of the most fundamental developments in elementary mathematics. In particular, the general statement formulated in the quotation under consideration is based on inferences which do not appear convincing to some of the best modern writers, as results from what was noted above, and teachers of mathematics should be interested in discussing with their students some of the reasons which have led to such dissenting observations.

One of the main benefits which a student may derive from a discussion of such quotations as those noted above is a recognition of the very serious difficulties which confront the student of the history of elementary mathematics. It is very easy to become familiar with various conclusions reached by eminent students of this subject, but when one meets with contradictory conclusions or with the consideration of the evidences upon which these conclusions were based very difficult questions present themselves. A brief history of our subject may be compared with a four-place logarithm table. To be most useful the fourth figure of such a table must frequently differ from the fourth figure of a more extensive table. Such differences do not imply actual errors. In fact, perfect agreement in the fourth place cannot be judged from the figures which appear in this place alone, just as perfect agreement between brief historical statements and the more extensive accounts cannot be determined from the outward form alone. These matters must be judged from the standpoint of the intended use, and brief formulations of historical views are often very valuable even if they need modifications when they are fitted into more extensive accounts.

In closing we desire to direct attention to only one more quotation from page 278 of the historical sketch under consideration, which is as follows: "The solution of the third and fourth degree equation was a sudden and tremendous advance. The complete solution of the quadratic had been perfected at least one thousand years earlier, and, as noted above, the Arabs had come to the conclusion that equations of higher degree could not be solved by algebraic methods." As the present writer has commented on similar statements found elsewhere it seems unnecessary to do much more here than to refer to these earlier comments[1]. It is perhaps sufficient to point out here that without the use of com-

[1]G. A. Miller, SCHOOL SCIENCE AND MATHEMATICS, vol 24, (1924), p. 509; *Proceedings of the International Mathematical Congress* (Toronto), 1924, p. 962.

plex numbers it is obviously impossible to give a complete solution of the quadratic equation from the modern point of view, and that no one has claimed that evidences which are now available establish the use of complex numbers in the general solution of the quadratic equation at least one thousand years before the solution of the cubic and the biquadratic equations by Italian mathematicians during the sixteenth century.

As the supplemental remarks noted above relate to a few of the most fundamental questions in the history of algebra it is hoped that they may be of interest also to those who are not familiar with the historical outline to which they explicitly relate. This contact is here noted only for the purpose of enhancing the interest in these remarks. The history of mathematics has a peculiar charm for many students of our subject and many teachers of mathematics have found that occasional references to this history are inspiring. Moreover, historical questions are frequently considered at the meetings of the mathematical clubs. Such considerations can frequently be made more permanently valuable if it is noted that widely circulated views relating to the history of our subject are frequently not free from vulnerable points, since the study of such points tends to deeper insight into mathematical as well as historical questions. The history of our subject cannot be fully appreciated without a profound insight into the mathematical questions involved therein.

The teacher of mathematics may reasonably be expected to become more sympathetic with his students if he acquaints himself with the great difficulty the human race encountered with views which our students are now expected to master easily. For instance, early in the seventeenth century a noted writer, C. Clavins, remarked in his algebra in regard to the rule relating to the multiplication of negative numbers that one has to ascribe to the weakness of the human intellect that it cannot comprehend why this rule is true. What is equally important is that a study of the nature of these difficulties tends to deepen mathematical insight and hence to better teaching. It is obvious that these ends can be attained more readily by a study of the reasons underlying historical conclusions than by merely collecting such conclusions. When one reads such a categorical statement as the one quoted above to the effect that the learned Brahmans did not use the abacus and then finds elsewhere that very little is known about the methods of computation in use in

India as early as the fourth century of our era one is inclined to wonder whether the former statement does not imply much more complete information in regard to early Hindu methods of calculation than we now possess. The student of mathematics is accustomed to ask for reasons and he should be encouraged to maintain this attitude in the study of the history of our subject.

FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE

By Duane Roller,
University of Oklahoma, Norman, Okla.

Nothing has tended more to retard the advancement of science than the disposition in vulgar minds to vilify what they cannot comprehend.—*Samuel Johnson.*

Science—in other words, knowledge—is not the enemy of religion; for, if so, then religion would mean ignorance. But it is often the antagonist of school-divinity.—*Oliver Wendell Holmes.*

The work of science is to substitute facts for appearances, and demonstrations for impressions.—*John Ruskin.*

Alchemy may be compared to the man who told his sons he had left them gold buried somewhere in his vineyard; where they by digging found no gold, but by turning up the mould, about the roots of their vines, procured a plentiful vintage. So the search and endeavors to make gold have brought many useful inventions and instructive experiments to light.—*Francis Bacon.*

The history of a science is the science itself.—*Goethe.*

A paradox is never terrifying to the scientist. Faraday wrote to Tyndall, "The more we can enlarge the number of anomalous facts and consequences the better it will be for the subject, for they can only remain anomalies to us while we continue in error."—*Gilbert N. Lewis in "The Anatomy of Science."*

Science seldom renders men amiable; women never.—*Beauchêne.*

A new principle is an inexhaustible source of new views. —*Marquis de Vauvenargues, philosopher.*

As we teach science today in our schools the effort of learning the quantitative relationships too frequently leaves neither the instructor nor the student leisure for fruitful inquiry or speculation as to the mechanism itself.—*John Mills in "Within the Atom."*

"SHALL LABORATORY WORK IN THE PUBLIC SCHOOLS BE CURTAILED"—A CRITICISM.

By Elliot R. Downing,

University of Chicago, Chicago, Ill.

The article in the January number of School Science and Mathematics on "Shall Laboratory Work in the Public Schools Be Curtailed" contained so many inaccurate and misleading statements that it demands some comment.

In the first place the word "advocate" connotes that such a person is concerned primarily in winning his case. This is not the attitude of the scientist. He is concerned primarily in discovering the truth and gives his allegiance to that side of the question that is upheld by the factual evidence. He is quite willing, even anxious, to change his opinion when new evidence demands such a change.

The article in question quotes Wiley as stating "in every respect the lecture (demonstration) method is the least effective in imparting knowledge to high school pupils." The quotation is inaccurate for the author has introduced the word in parenthesis. Wiley was investigating the relative merits of the textbook, lecture and laboratory methods. He did not use in his investigation the lecture demonstration method. It is just such distortion of data that characterizes the advocate and is condemned by the scientist.

The article in question states that "greater retention resulted from the individual laboratory method as evidenced by the delayed recall scores." While this statement is true the significance of it is quite altered when it is also stated that in those experiments in which the tests were subdivided into the elements involved it was evident that the superiority of the scores in the delayed tests depended on the better ability of the students to recall how apparatus was set up and what happened in the experiment but that on the purpose of the experiment and the significance of the experiment the demonstration method gave superior results even in the delayed tests.

Walters has shown (Master's Thesis, University of Chicago, School of Education) that by using the time saved by the lecture demonstration method in drilling on the set up of apparatus and what happens in an experiment, the demonstration method can be made to yield superior results to the laboratory method on these items if that seems desirable.

The article referred to quotes with approval, Cunningham's statement that "it is not safe to make sweeping generalizations as to best laboratory methods from these data." Since Cunningham wrote this a great deal of additional evidence has come to hand. Wiley and Cunningham were the two first men to investigate this problem of the relative merits of the laboratory method in comparison with other methods of instruction in science. Now more than two dozen experienced teachers have taken part in the investigations and the experiments have involved over 4,000 pupils. The investigations have been quite unanimous in concluding that the demonstration method is as good as or superior to the individual laboratory method in imparting essential knowledge, in developing skills in their initial stages and in giving facility in scientific thinking. Relatively few of the investigations, however, have dealt with the last two points. Moreover, the demonstration method saves considerable time, 90 per cent or more of the running expense in experimental work and a large amount of initial equipment.

The problems involved in the whole question are intricate and need many additional investigations before their satisfactory settlement but certainly the evidence in hand throws the burden of proof of the superiority of individual laboratory work on to the shoulders of those who persist in its use in general courses. There seems little doubt but that those pupils who are going into professions or callings that will require skillful laboratory practice must ultimately develop such skill by individual manipulation though even that has not yet been proven by critical experiments.

The article says that "improvement in laboratory work . . . will come through the redirection of pupil activity rather than the shifting of the activity from pupil to teacher. . . . It is one of the most fundamental principles of education that self activity educates." The implication is that in laboratory work the pupil is doing things while in demonstration he is passive. The author criticizes the experiments that have been done on the relative merits of the demonstration and individual laboratory methods and claims that they have not established that demonstrations are superior to laboratory procedure "in which pupils take the initiative and carry on the activities."

The teachers who have conducted these experiments were excellent teachers. The laboratory work under their direction was conducted in a manner superior to the average laboratory

work. More than that, some of the investigations have tested out the relative merits of the two methods to determine the ability of pupils to take the initiative and carry on the activities.

No one questions that self activity educates—that we learn by doing. But we learn to do what we do. If it is desirable to teach pupils in chemistry to bend glass tubing, to wash glassware, to pour chemicals from a bottle into a test-tube, undoubtedly they learn these best by doing these things. But if we want them to observe accurately; to analyze a complex situation and pick out the essential elements; to formulate and test hypotheses; to reason accurately on the basis of facts; to pass critical judgments; to understand the purpose and significance of the experiment, the facts established in the numerous experimental studies seem to indicate that students do these things better by the demonstration method than by the laboratory method. One would almost anticipate this for certainly the teacher can supervise the mental habits that are being formed; the thought processes that are going on much more readily when he can quiz pupils by rapid fire of questions as the demonstration proceeds than he can in the laboratory where students are scattered and where very much of his time is occupied in issuing and recording supplies and apparatus.

The author of the article referred to is apparently quite willing to abandon the laboratory method for the project method though he seems to regard the project method merely a modification of the laboratory method. In the interests of clarity in our discussions it seems advisable to let the term laboratory method mean what it has come to mean through long usage. Let us then continue the experiments on the relative merits of the laboratory and the project methods.

Certainly the evidence in hand for the superiority of the project method over the laboratory method is nowhere nearly as convincing as the evidence of the superiority of the demonstration method over the individual laboratory method. Miss Garber's article, which the article in question quotes with approval, shows an average superiority in the three tests she uses of 2.15 points. The data in Mr. Watkins' thesis are more abundant and yet such a variety of teaching devices is included in the project method in both of these studies that they do violence to one of the fundamental rules of any experiment—that there shall be only one variable present—that one the factor whose influences one is endeavoring to evaluate.

A SIMPLE, PRACTICAL PROBLEM IN ANALYSIS.

By G. T. Franklin;

Lane Technical High School, Chicago.

A short time ago a teacher asked me rather abruptly:—"What is a good method for high school pupils to use in the analysis of baking powders?" The tone of the voice suggested that he was not satisfied with the results of the method being used. Partly because I did not know very much about the subject, partly because I wanted to evade the proposition, since why should anyone care to worry about it, I answered to the effect that "there is no satisfactory method for high school pupils to use in the analysis of baking powders." There are so many good problems in general chemistry for high schools that it seemed to me that baking powder with its difficulties might be overlooked. The matter kept recurring to my mind, however, and as is usually the case of a good suggestion well-placed, sooner or later it begins to bear fruit. It occurred to me that analysis in chemistry after all is largely a matter of problematic situations, which put the pupil to the test for solution by putting into use knowledge previously learned. It occurred to me that of all the parts of a text book, those which the learner dreads the most, are the questions at the end of the chapters. To acquire facts is one thing, to apply them to the solution of problems is another. The latter, while the most difficult for the beginner, is after all the whole thing. Therefore, there should be as many exercises as possible in the beginning course in chemistry to put the pupil's knowledge to the test. Granted that the pupil, who is unable to apply to general situations the method of solving special problems, is of poor ability and will generally not succeed very well in scholarship and that it makes little difference as to the "practical" nature of the problems given him, yet, it is safer to include problems that in some way apply directy to people's every day activities. The baking powder problem fills this need.

Up to this time I had considered it quite enough to make a brief discussion of the subject in the class room accompanied by a little laboratory exercise, which taught very little except that certain substances in water solution turn blue litmus red, and that another yields carbon dioxide very rapidly with the addition of hydrochloric acid. It seemed sufficient to me to show in a few sentences that all baking powders yield carbon-dioxide when moistened, that to do so some compound must be

used in the powders to produce it, that without exception in modern baking powders sodium bicarbonate is used for the purpose. It seemed to me perfectly obvious that to set free carbon dioxide some acid-forming substance is necessary. It also seemed to me that the pupil would see the idea immediately. A little mental analysis was indulged in by pupil and teacher relative to the kind of acid substance that would be suitable in the baking powders. The names of the substances ordinarily used were finally written on the board and the various combinations used in factory-made baking powders discussed. A little more elaboration and a few questions answered by a few of the brighter members of the class and the job was considered done and no more worry about baking powders, for the present. The worry came however, with the written quiz, which registered mostly failures of the pupils' efforts. Many appeared to have missed the whole idea entirely.

Finally, I decided to experiment for myself in the hope of bettering my instruction by use of the laboratory. Success in the method previously applied to the study of hard waters gave me encouragement. The compounds used in baking powders made ordinary schemes of qualitative analysis quite useless for high school. A glance showed that a test for sulphate ion would be sufficient to confirm or deny the presence of sodium-aluminum sulphate, the only sulphate compound used in baking powders. A simple test for tartrate ion would suffice for potassium acid tartrate and trataric acid. Since only one company of wide reputation uses these substances in baking powders, any effort to distinguish one in the presence of the other would be superfluous and rather difficult for the beginner, the tartrate test was considered sufficient. A test for phosphate ion indicated as present or absent the monobasic salt of sodium or calcium. While search failed to reveal any commercial brand of baking powders containing monosodium phosphate, yet writers on the subject include it. This made it desirable to test for sodium or calcium. A test for starch concluded the study. The task of writing the instructions seemed easy, but not so easily carried out. Many changes were found necessary before they were considered fit for the pupils. The preparation of a water solution was tried and abandoned. By this method most of the dicalcium phosphate formed by the reaction remained behind on the filter, and in case of a double baking powder, aluminum phosphate remained with the

residue. While the extreme sensitivity of the molybdate test for phosphate ion invariably gave the test when this ion was present in the original, only traces of calcium could be detected. A nitric acid solution was then tried with better success. The acid not only decomposed slightly soluble and insoluble phosphates of the water solution, but assisted materially to coagulate colloidal matter and thus made filtration easier. The test for calcium was decisive. The exercise was now ready for the pupil. "Unknowns" involving common brands of baking powders were used. Many completed the problem without difficulty. Others complained of the slowness of the solution to pass through the filter and that it was not entirely clear when it did go through. The reason was apparent. Some baking powders have in them a small portion of dried white of egg. This clogged the pores of the filter and partly passed through. Those, who were given this type of baking powder, obtained the result only after much delay. Since all brands containing this extra ingredient are easily duplicated in other respects, it was then decided to use only those free of dried white of egg and leave to the other fellow the solution of the complication.

When the written reports were received from the pupils, it was quite obvious that some drastic changes and additions to the instructions were needed. It was quite apparent as previously stated that the class room instruction did very little good to many. It was far from obvious to many that the tests were used to identify ions and not compounds, and that the presence of the ion indicated a certain compound used in the baking powders. Numerous questions were used to keep this before the pupil while at work. Finally, the pupil was required to do what seemed at first unnecessary,—make a complete list of the compounds used to make the baking powder he studied.

The sensitivity of a nitric acid solution of ammonium molybdate for phosphate ion and the ease with which it is used, caused me to include it in the final written instruction sheet. The "mirror" test for tartrate ion in alkaline solution was tried and abandoned for a simpler test but one probably less valuable to the chemistry point of view. The trouble with this test is the fact that it is difficult to describe to the pupil so that he recognizes it without some one having previously shown it to him. He is often so bent on making the test "work"

that he gets a slight odor of sulphur trioxide and immediately interprets it as the test. It is probably better to have the pupil make the blank test first and then try the "unknown," or work a few samples through with the label on the can before him.

The following is the instruction sheet submitted for your critical study. Any criticisms, corrections, changes, additions will be gratefully received by the author.

ANALYSIS OF BAKING POWDERS.

TEST FOR CARBONATE:—To about 2g of baking powder in a small beaker add 25cc of water and stir. What gas is evolved? What acid radical is indicated by this gas? What compound in the baking powders produces the gas? After the action has continued for a time add dilute nitric acid, a few drops at a time, with stirring, until the mixture tests acid after thorough stirring. Add one or two cubic centimetrs more of the acid and filter. Save filtrate and residue. The filtrate should be clear.

TEST FOR PHOSPHATE:—Warm about 5cc of ammonium molybdate solution and add a drop or two of the filtrate. A yellow precipitate indicates phosphate. What compounds in the baking powders may be present as indicated by a positive test?

TEST FOR CALCIUM:—To a portion of the filtrate add ammonium hydroxide until alkaline. If a precipitate forms add scetic acid until it dissolves. If no precipitate forms add acetic acid until the solution tests acid after shaking. In either case add a solution oxalate and allow to stand. A white precipitate indicates calcium. What compound in the baking powders is indicated by a positive test?

TEST FOR TARTRATE:—Evaporate about ten cubic centimeters of the fitrate near to dryness and then add a few drops of concentrated sulphuric acid. Charring with odor or burnt sugar, indicates tartrate. What compounds may be present in the baking powder as indicated by a positive test?

TEST FOR SULPHATE:—To another portion of the filtrate add barium chloride solution. A white precipitate insoluble in hydrochloric acid indicates sulphate ion. (The addition of the HG1 is unnecessary if the right quantity of nitric acid was used to make the solution.) The test should be decisive. A trace of sulphate as impurity is frequently found in baking powders. A positive test indicates what compound in the baking powders?

TEST FOR STARCH:—Heat a beaker of water to boiling and stir into the water a portion of the residue on the filter. Cool the mixture and add a little iodine solution. A blue color indicates starch.

Make a list of the compounds in the baking powders analyzed.

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,
University of Michigan, Ann Arbor, Mich.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, 204 Mason Hall, University of Michigan, Ann Arbor, Mich.

LATE SOLUTIONS.

1037. *Junius J. Hayes, Salt Lake City, Utah.*
1048. *E. de la Garza, Brownsville, Texas.*
1042. *A. Vaidliyanadhan, Tanjore, Madras.*

Editor. Comment on solution of Problem 1032, in January, 1929.

Mr. Sergent calls my attention to the fact that the areas of the first and second prisms are not equal, one area is 310.66 sq. ft. and the other is 310.69 sq. ft.

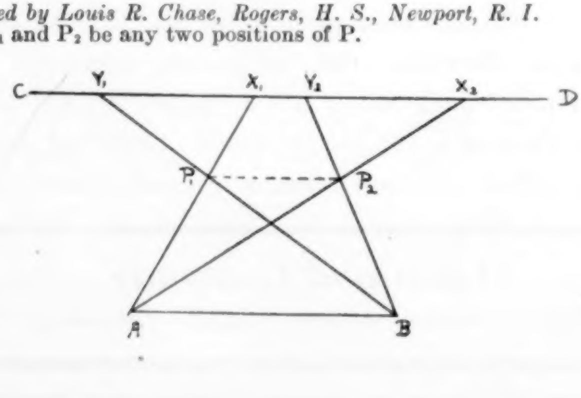
SOLUTIONS OF PROBLEMS.

1049. *Proposed by R. T. McGregor, Elk Grove, Calif.*

A and B are two fixed points: CD is a line parallel to AB. X and Y are two variable points on CD such that XY is of constant length. AX and BY meet in P. Show that the locus of P is a straight line parallel to AB.

I. *Solved by Louis R. Chase, Rogers, H. S., Newport, R. I.*

Let P_1 and P_2 be any two positions of P.



Since CD is parallel to AB,

$$\triangle\ ABP_1 \text{ is similar to } \triangle\ X_1Y_1P_1;$$
$$\triangle\ ABP_2 \text{ is similar to } \triangle\ X_2Y_2P_2.$$
$$\therefore\ AP_1/X_1P_1 = AB/XY = AP_2/X_2P_2.$$

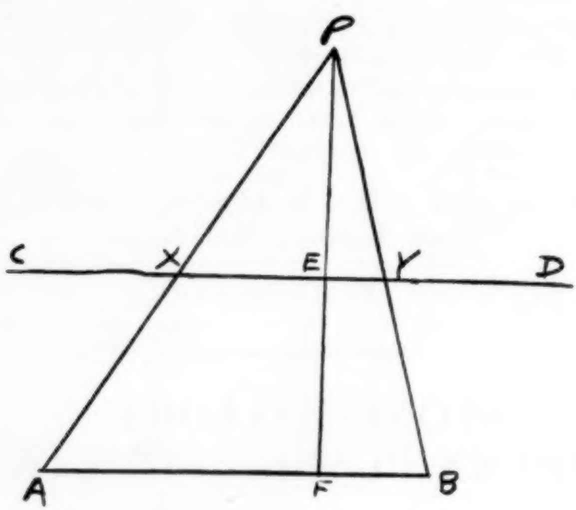
The preceding relation shows that X_1X_2 is parallel to P_1P_2.

$$\therefore\ P_1P_2 \text{ is parallel to } AB.$$

If P_3 be any point on P_1P_2, by proportions of the sides of similar triangles it is easily shown that lines from P_3 through A and B will intersect on CD a segment equal to XY. Therefore the locus of P is a straight line parallel to AB.

II. *Solved by F. A. Cadwell, St. Paul, Minn.*

From the point P draw a $\perp$ to XY and AB, intersecting XY at E and AB at F.



$\triangle$s PAB and PXY are similar.

$$\therefore\ AB/XY = PF/PE.$$

Hence $$\frac{AB-XY}{AB} = \frac{PF-PE}{PF} = \frac{EF}{PF}.$$

Since $(AB-XY)$, AB, and EF are constants, PF is a constant. Therefore the locus of P is a straight line parallel to AB at the distance FP from AB.

III. *Solved by the Editor.*

Analytic Solution. Given $A(0,0)$, $B(a,\ 0)$ and the equation of CD as $y=c$, and the constant length of XY as d, the coordinates of $P(h,\ k)$. The line PB cuts the line CD at the point $[(ch+ak-ac)/k,\ c]$, and PA cuts the line CD at the point $(ch/k,\ c)$. Hence $ak-ac=d$, or

$$k = ac/(a-d),$$

which is the equation of a line parallel to AB. Two results are obtained according as $a<d$ or $a>d$.

Also solved *William A. Kaye, San Francisco, Calif.; Mary E. Balan, Fayetteville, N. C.; Sudler Bamberger, Harrisburg, Pa.; J. Murray Barbour, Aurora, N. Y.; J. Ross Adams, Rothville, Mo.; J. F. Howard, San Antonio, Texas; Milton F. Prue, Tarrytown, N. Y.; M. W. Coultrap, Naperville, Ill.; A. H. Heiby, Chicago, Ill.; George Sergent, Tampico, Mexico;* and the *proposer.*

1050. *Proposed by Norman Anning, University of Michigan.*

A student finds for

$\sqrt{1-4X}=1-2X-2X^2-4X^3-10X^4-28X^5-84X^6- \ldots$ He infers that the coefficients of all succeeding powers of X will be negative integers. Prove that he is right.

Solved by J. F. Howard, San Antonio, Texas.

Expanding $(1-4X)^{1/2}$ by the binomial theorem one will find that the coefficient of the nth term contains $(n-1)$ negative factors, and the factor $(-4X)^n$ contains n negative factors. Hence the nth term contains $(2n-1)$ or an odd number of negative factors, and is negative.

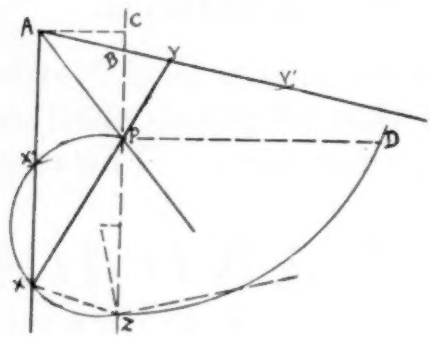
Also *solved by J. Murray Barbour, Aurora, N. Y.;* and by *M. W. Coultrap, Naperville, Ill.*

1051. *Proposed by Nathan Altshiller-Court, University of Oklahoma.*

Through a given point on the bisector of an angle to draw a line so that the segment intercepted on it by the sides of the angle shall have a given length.

Solved by George Sergent, Tampico, Mexico.

First Solution. Suppose the problem solved and let $XY=k$ be the segment intercepted on the line through P by the sides of the given angle A. Draw through P the $\parallel$ to XA, cutting YA in B, and from X a line making with XY an angle equal to angle A, and cutting BP produced in Z. Let $PB=BA=a$, and $PZ=x$.



The $\triangle$s XPZ, BPY, AXY are similar. Then

$$XZ : PX = AY : AX = PY : PX, \text{ hence } XY = PY.$$

In the $\triangle$ PXZ, we have, substituting PY for XZ

$$x^2 = (PX)^2 + (PY)^2 - 2(PX)(PY)\cos A. \qquad (1)$$

By hypothesis $PX+PY=k$; by similar $\triangle$s XPZ and BPY we have

$$PX : a = x : PY, \text{ hence } (PX)(PY) = ax.$$

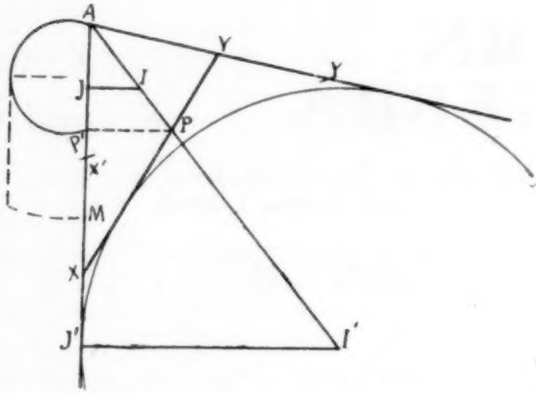
Then $(PX)^2+(PY)^2=k^2-2ax$, and, substituting in (1) we have

$$x^2+2a(1+\cos A)x-k^2=0,$$

whose roots can be constructed.

Construction. Draw through P a $\parallel$ to the side of the given angle, intersecting the other side in B; from A the $\perp$ AC to PB, produced if necessary. At P draw to BP the $\perp$ $PD=k$, the given length. With C as a center and CD as radius draw a circle intersecting BP produced in Z, within the given angle. On PZ as chord draw the arc containing an angle equal to angle A, and intersecting in X the side $\parallel$ to PZ. The line through P and X is the required line.

Second Solution. Let XAY be the $\triangle$ formed by the segment $XPY=k$, and the sides of the given angle A; P the given point on the bisector, I the center of the incircle, I′ the center of the escribed circle; P′, J, J′ the orthogonal projections of P, I, I′ on AX. (AP, II′) is an harmonic range; likewise (AP′, JJ′). Let M be the midpoint of JJ′. We have $(k/2)^2=(MA)(MK)$. $k/2$ is the length of the tangent from M to any circle drawn on AP′ as a chord. M can be determined, then J and J′ by $MJ=MJ'=k/2$.



Construction. Draw PP′ ⊥ to a side of the given angle. Draw any circle passing through A and P′, and the locus of the extremities of the tangents equal to $k/2$ that can be drawn to this circle. Its intersection with AP′ produced determines M. Mark off on AP′ from M on either side MJ = MJ′. The ⊥s at J and J′ determine I and I′ on the bisector AP. The common tangent to the circles I and I′ is the required line.

Editor. Note by the Proposer. This problem is known as Pappus problem and has received a great deal of attention. See College Geometry, Altshiller-Court, page 68, Johnson Publishing Co., Richmond, Va.

Also solved by *Bessie B. Green-Andrews, Wichita, Kansas; Russel M. Babcock, Aberdeen, South Dakota; Louis R. Chase, Rogers H. S., Newport, Rhode Island; F. A. Cadwell, St. Paul, Minnesota; A. H. Heiby, Chicago, Illinois;* and the *Proposer.*

1052. *Proposed by Samuel I. Jones, Nashville, Tenn.*

Write any number of four figures in descending order. Reverse the order of the digits and substract. Again reverse the order of the digits and add. The sum is always 10890. Why?

Solved by Louis R. Chase, Rogers High School, Newport, R. I.

Given digits A, B, C, D, such that A > B > C > D.

Let the number be written in our decimal system, using the letters just as we use digits.

Given number	A	B	C	D
Number reversed	D	C	B	A
Difference	A − D	B − 1 − C	9 + C − B	10 + D − A
Diff. reversed	10 − A + D	− B + 9 + C	− 1 − C + B	− D + A
Sum	10	8	9	0

In the above operations, "borrowing" and "carrying" are resorted to just as in our decimal arithmetic, bearing in mind the relationship, A > B > C > D.

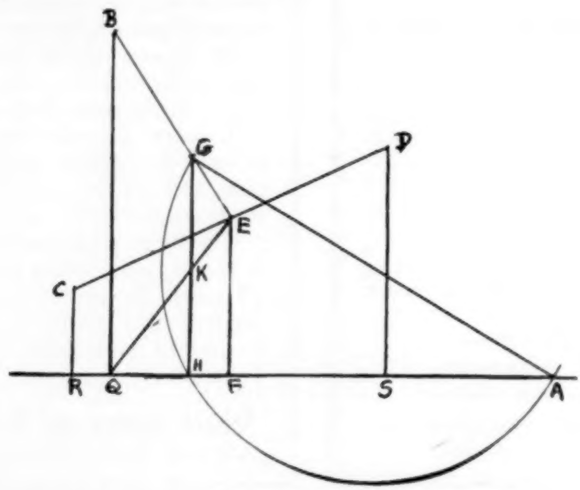
Also solved by *J. Murray Barbour, Aurora, N. Y.; R. M. Babcock, Aberdeen, So. Dak.; M. W. Coultrap, Naperville, Ill.; Sudler Bamberger, Harrisburg, Pa.; H. D. Grossman, Brooklyn, N. Y.; Daniel Kreth, Wellman, Iowa; A. H. Heiby, Chicago, Ill.; A. L. McCarty, San Francisco, Calif.; J. F. Howard, San Antonio, Texas; E. de la Garza, Brownsville, Texas; George Sergent, Tampico, Mexico;* and *Meyer B. Tope, Wilkes-Barre, Pa.*

1053. *Proposed by George Sergent, Tampico, Mexico.*

Given four points A, B, C, D; to draw through A a line so that if perpendiculars BQ, CR, DS are drawn to it, the sum of these perpendiculars is equal to a given length.

I. *Solved by F. A. Cadwell, St. Paul, Minn.*

Construction. Draw CD and find E, its midpoint; draw EB, and on EB take EG = EB/3. On AG as a diameter construct a semicircle. In the semicircle draw a chord, GH, equal to 1/3 the given length. Then AH is the required line.



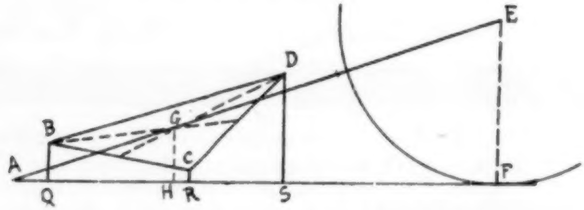
Proof. Drop a $\perp$ from E to AH. BQ, CR, DS, and EF are parallel to GH. Draw QE intersecting GH at K. GK = BQ/3, and QK = 2QE/3, hence KH = 2EF/3. Then

$$GK + KH = GH = BQ/3 + 2EF/3. \tag{1}$$

Since E is the midpoint of CD, 2EF/3 = (CR + DS)/3. Substituting in (1) we have GH = (BQ + CR + DS)/3. By construction GH is equal to 1/3 the given length.

II. *Solved by the Proposer.*

Construction. Determine the center of gravity, G, of the $\triangle$BCD. Draw AG and lay off on it from A, AE = 3AG. With E as a center and the given length as a radius draw a circle. Draw from A the tangent AF to this circle. AF is the required line.

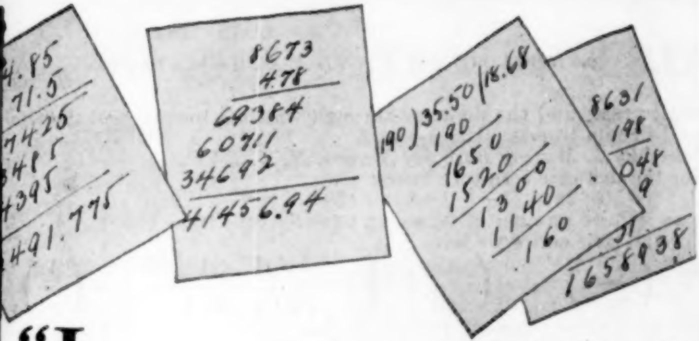


Proof. Draw GH, BQ, CR, and DS parallel to EF, hence $\perp$ to AF GH = EF/3. The coordinate GH, of the center of gravity, is the average of the coordinates of the vertices of the $\triangle$BCD.

Also solved by *Louis R. Chase, Newport, R. I.; L. Wayne Johnson, Norman, Okla.; Bessie B. Green-Andrews, Wichita, Kansas;* and *J. F. Howard, San Antonio, Texas.*

1054. *Proposed by the Editor.*

Conditions are such that a ball falls 50 feet and rebounds 25 feet; then falls 25 feet and rebounds 12.5 feet, and so on. Assume that the ball



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comes to rest, find the distance through which it moves, and the time it takes to come to rest. Use $g=32.2$.

Solved by J. Murray Barbour, Aurora, N. Y.

For the distance series we have

$$S=50+2x25\ (1+1/2+1/4+1/8+\ldots\ldots+1/2^n).$$

For an infinite number of terms we have $S=50+100=150$ ft.

For the time series we have

$$T=\left(\frac{50}{16.1}\right)^{1/2}+2x\left(\frac{25}{16.1}\right)^{1/2}\left[1+\frac{1}{\sqrt{2}}+\frac{1}{2}+\frac{1}{2\sqrt{2}}+---+\left(\frac{1}{2^n}\right)^{1/2}\right]$$

For an infinite number of terms we have

$$T=\left(\frac{25}{16.1}\right)^{1/2}\left[\sqrt{2}+4+2\sqrt{2}\right]=10.27 \text{ sec.}$$

Editor. Several solutions were received giving the correct answer for the distance, but a wrong answer for the time.

Also solved by *Melvin Dresher, Hackensack, N. J.; J. F. Howard, San Antonio, Texas; A. H. Heiby, Chicago, Ill.; Louis R. Chase, Newport, R. I.; M. W. Coultrap, Naperville, Ill.; R. T. McGregor, Elk Grove, Calif.; Edwin L. Key, Gaylesville, Alabama; Russel Babcock, Aberdeen, So. Dak.; Sudler Bamberger, Harrisburg, Pa.;* and *Euclidean Math. Club of Enid, Okla., H. S.*

PROBLEMS FOR SOLUTION.

1067. *Proposed by Norman Anning, University of Michigan.*

The real quadratic equations

$$ax^2+bx+c=0,$$
$$bx^2+cx+a=0,$$

are to have a common root. Show that $a+b+c=0$ is a sufficient condition but not a necessary one.

1068. *Proposed by George Sergent, Tampico, Mexico.*

Given O–ABC a tetrehedron with tri-rectangular trihedral angle at O. Designating by h the altitude from O to the base ABC, and by a, b, c the edges OA, OB, OC, prove the relation.

$$1/h^2=1/a^2+1/b^2+1/c^2.$$

1069. *Proposed by Daniel Kreth, Wellman, Iowa.*

A boy buys 80 marbles for 80 cents. A blue marble costs 4/3 of a cent; red costs 5/4 cent; white costs 9/25 cent. How many marbles of each color does he buy? Solve by alligation.

1070. *Proposed by R. T. McGregor, Elk Grove, Calif.*

AB the base of a triangle is fixed, and k the sum of the other two sides is given. Prove that the locus of the foot of the perpendicular from B to the bisector of the exterior vertical angle is a circle whose diameter is k.

1071. *Proposed by the Editor.*

If perpendiculars be drawn to the sides of a regular polygon of n sides from any point on the inscribed circle whose radius is a, prove

$$\frac{2}{n}\sum\left(\frac{p}{a}\right)^2=3, \text{ and } \frac{2}{n}\sum\left(\frac{p}{a}\right)^3=5.$$

1072. *Proposed by E. de la Garza, Brownsville, Texas.*

9 is the square root of 81, and $8+1=9$: 45 is the square root of 2025, and $20+25=45$; 55 is the square root of 3025, and $30+25=55$. Find a number of six figures satisfying the same condition.

SCIENCE QUESTIONS.

Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

Send in your interesting problems, your questions, your solutions, and your examination papers.

PACKARD'S MONKEY PROBLEM PUZZLES LAKE MILLS GIRLS.

Lake Mills, Iowa, Feb. 19, 1929.

Dear Sir:

A few of us girls were trying to get that problem about the monkey.

None of us agree so we would like to ask a favor of you. We have been trying to work it in the simultaneous method, because we have been studying that in Algebra.

I am sending a stamped envelope. So please if you have time work that problem in the simultaneous method and send it to me. Please send it right away if possible, because we will be together on Tuesday. Thanking you for the same.

Yours truly,

Miss Vivian Dahl.

Lake Mills, Iowa, Feb. 25, 1929.

Dear Sir:

We received your letter tonight. We want to thank you so very much for your kindness, time, bother, and promptness. Your letter reached us the day before Tuesday. The girls certainly appreciated your thoughtfulness and kindness in answering our letter. We found by your answer that we were not so very far off. The answer we got was 5 1-3 ft. You have solved our problem entirely. We have studied and found our mistake. We will surely be on the lookout for that cocoanut problem.

Thanking you for your aid and kindness I will close.

Yours sincerely,

Vivian Dahl.

This solution settled the question.

526. *Solution by R. J. Bignall, Sanborn, North Dakota.*

Here is a solution to Packard's 526 with fewer unknowns.

Let $6\times$ = age of mother when she was 3 times as old as the monkey was.

$2\times$ = age of monkey then.

$4\times$ = difference in ages.

$18\times$ = age the monkey will be when 3 times, etc.

$9\times$ = age the mother when 1-2 as old as monkey was, when, etc.

$(9\times - 4\times) = 5\times$ = age of monkey at same time.

$10\times$ = age the mother is.

$6\times$ = age the monkey is.

$(10\times + 6\times) = 16\times = 4$ years or combined ages.

$\therefore \times = 1\text{-}4$ yr.

Then Mother is $2\frac{1}{2}$ yrs. old.

Also weight and Monkey weigh $2\frac{1}{2}$ lbs.

Let R be weight of rope.

$2\frac{1}{2} + R = 3/2\ (2\frac{1}{2} + 2\frac{1}{2} - 2\frac{1}{2})$.

$R = 5/4$ lbs.

$(5/4 \times 16) \div 4 = 5$.

$\therefore$ Rope is 5 ft. long.

Other solutions in School Science and Mathematics, February, 1929, pages 212-13.

THE FAMOUS COCOANUT PROBLEM.

532. *Proposed by E. A. Hollister, Pontiac High School and Junior College, Pontiac, Michigan.*

Here is another monkey problem to tease the analysts.

Four sailors and a monkey have spent the day gathering cocoanuts which they decide to divide equally the next day. It happens that each sailor mistrusts the others and each one steals out alone during the night to get his share. Each divides the pile he finds into four equal parts and takes his share away. In each case there is one odd cocoanut which is given to the monkey. On the following day they meet and divide the remaining pile into four equal parts of which each one takes one part and again there is one left which they give to the monkey. How many cocoanuts in the original pile and how many does each sailor get?

My solution is $N = \times(4)^5 - 3$ where $\times$ may be any integer.

Don't ask me how I got it. It was a long and laborious process.
If $\times = 1$ from above $N = 1021$.
1st sailor gets 255 + 80 or 335.
2nd sailor gets 191 + 80 or 271.
3rd sailor gets 143 + 80 or 223.
4th sailor gets 107 + 80 or 187.
Monkey gets..............................5.
1052
If $\times = 2$ $N = 2045$, etc.
Please send in other solutions.

SOLUTIONS AND ANSWERS.

527. *Proposed by Prof. Douglas I. Bates, College of Engineering, Oregon Institute of Technology, Portland, Oregon.*

When the air about an organ pipe changes temperature, which changes, the frequency or the wave length of the sound, if we neglect any expansion or contraction of the organ itself?

Solution by a Contributor.

The wave length of the sound will change. The frequency is determined by the length of the organ pipe, and, since we are to consider this length as constant, the frequency will be constant. If the air around the pipe changes in temperature there will be a corresponding change in the velocity of the sound wave by 60 cm. per sec. per degree C.

Using the formula $v = l\,n$, we see right away that, if n is constant, v and l must change in the same ratio. The sound reaching the ear will be slightly different in pitch from the sound that left the organ pipe.

(I may be wrong. Please check me up. *Contributor.*

529. *Proposed by Sudler Bamberger, Harrisburg, Pa.*

A motorist, traveling on a level road at 40 miles per hour sees something ahead. He applies his brakes on the car and comes to a stop with a uniform acceleration. If he stops in 30 seconds, how far did he travel before coming to a stop?

Solution by "Autoist," Brownsville, Texas.

If the motorist stops his car in 30 seconds, while traveling at the rate of 40 miles per hour, or its equivalent $\frac{40 \times 5280 = 1920}{60}$ feet per minute, his regulative acceleration is 3840 feet per minute. The distance traveled is given by the formula

$$e = v\,t - \tfrac{1}{2}\,a\,t^2 = \frac{1920}{2} - \frac{3840}{8} = 960 - 480 = 480 \text{ feet.}$$

Note—A car with good brakes should stop at a distance of about 148 feet while traveling at 40 miles per hour, and in about 5 seconds.

529. *Two solutions by E. A. Hollister, Pontiac High School and Junior College, Pontiac, Mich.*

(1)

$$v = 40 \text{ mi/hr.} = \frac{176}{3} \text{ ft./sec.}$$

$$t = 30 \text{ sec.}$$

$$s = ?$$

$$v = at$$

$$a = \frac{v}{t} = \frac{176}{3} \div 30 = \frac{176}{90} \text{ ft/sec.}^2$$

$$v^2 = 2\,a\,s$$

$$s = \frac{v^2}{2a} = \frac{176 \times 176}{3 \times 3} \div \frac{176}{45}$$
$$= 880 \text{ ft.}$$

(2)

$$s = \frac{vt}{2} = \frac{176}{3} \times \frac{30}{2} = 880 \text{ ft.}$$

$$\text{from}\left[s = \frac{v - v_0}{2} t\right]$$

Now, Mr. Autoist, it is up to you to prove that brakes work just the same in Michigan as in Texas. And, Mr. Hollister, what do you say?

TEST QUESTIONS.

531. *Questions from Harry E. Williams, Ironton High School, Ironton, Ohio.*

Try out these questions on your class and write your report to the Editor. *Send your own examination paper.*

SEMESTER EXAMINATION—PHYSICS.

Ironton High School, Ironton, Ohio.

The examination covers the following topics: *Metric system, simple machines, mechanics of liquids and gases, force and motion, falling bodies, expansion* and *transmission of heat.*

(Continued from the *March* number of SCHOOL SCIENCE AND MATHEMATICS where the first 61 questions are in print.)

Work the following problems in the space provided and place your answer on the line to make the statement complete and true.

62. A water tank has a flat bottom whose area is 150 sq. ft. and the water in the tank is 8 ft. deep. The total downward force on the bottom of the tank is..............................lbs.

(In the original examination space for working the problem follows each question.)

63. Under a pressure of 15 lbs. per square inch a certain mass of air has a volume of 100 cubic feet. Under a pressure of 300 pounds per square inch the same mass has a volume of ....cubic feet.

64. A boat weighs 500 lbs. It displaces..............................lbs. of water.

65. A force of 25 lbs. was required to push a box along the floor. It was pushed a distance of 4 ft. The work done was.............................. ft. lbs.

66. A certain mass weighs 50 lbs. Its weight if the force of gravity were doubled would be..............................lbs.

67. The acceleration due to gravity is 32.16 ft. per sec. per sec. It takes 5 seconds for a stone to fall to the bottom of a ravine. The ravine is..............................ft. deep.

68. A piece of cast zinc weighs 700 grams. Its volume is 100 cubic centimeters. Its density is..............................grams per cubic centimeter.

69. A man rolls a 200 lb. barrel up a plank 10 ft. long onto a platform 4 feet high. The force required is..............................lbs.

70. The mechanical advantage of the handle of an ordinary lift pump whose arms are 25 inches and 5 inches respectively is.............................. ....

71. Make a diagram of a system of pulleys whose mechanical advantage is 5 showing a suitable resistance and effort.

72. Make two diagrams of the common lift pump showing the essential parts, the action of the valves and position of the water after the pump is operating well (1) during the upstroke of the piston (2) during the downstroke of the piston.

(*Continued in May.*)

BOOKS RECEIVED.

Community Hygiene by Dean Franklin Smiley, Medical Adviser and Assistant Professor of Hygiene in Cornell University and Adrian Gordon Gould, Assistant Medical Adviser and Assistant Professor of Hygiene in Cornell University. Cloth. Pages x+350. 13x20 cm. 1929. The Macmillan Company, New York.

Textbook of Evolution and Genetics by Arthur Ward Lindsey, Professor of Zoology in Denison University. Cloth. Pages xii+459. 14x21.5 cm. 1929. The Macmillan Company, New York.

New Practical Physics by Newton Henry Black Assistant Professor of Education, Harvard University and Harvey Nathaniel Davis, Presi-

dent of Stevens Institute. Cloth. Pages x+645. 12.5x19 cm. 1929. The Macmillan Company, New York. Price $1.20.

Soap Bubbles by Ellen Beers McGowan, School of Household Arts, Teachers College, Columbia University. Cloth. Pages viii+248. 13.5x18.5 cm. 1929. The Macmillan Company, New York. Price 80 cents.

Our Farm World, A Source Book in General Agriculture by Fred T. Ullrich, Director of Agricultural Education, State Teachers College, Platteville, Wisconsin. Cloth. Pages xi+603. 13.5x20 cm. 1929. Longmans, Green and Company, 55 Fifth Avenue, New York. Price $4.00.

Identification and Properties of the Common Metals and Non-Metals by J. E. Belcher and J. C. Colbert, Assistant Professors of Chemistry in the University of Oklahoma. Paper. 45 Experiments. 21x27 cm. 1929. The Century Company, 353 Fourth Avenue, New York. Price $1.75.

The Branom Practice Tests in Elementary Geography by M. E. Branom, Head of Department of Geography, Harris Teachers College, St. Louis, Missouri. Paper. 84 Lessons. 22x28 cm. 1929. The Macmillan Company, New York. Price 68 cents.

Orleans Geometry Prognosis Test by Joseph B. Orleans, Chairman of the Department of Mathematics, George Washington High School, New York City and Jacob S. Orleans, Formerly of the Educational Measurements Bureau New York State Department of Education. World Book Company, Yonkers, New York. Package of 25, $1.70.

Schorling-Clark-Potter Arithmetic Test by Raleigh Schorling, Head of Department of Mathematics, the University High School, and Professor of Education, University of Michigan, John R. Clark, The Lincoln School, Teachers College, Columbia University and Mary A. Potter. Supervisor of Mathematics, Public Schools, Racine, Wisconsin. World Book Company, Yonkers, New York.

Some Publications of the Singerland-Comstock Co., Ithaca, N. Y. The following leaflets, 3¾x6¾ inches, suitable for loose-leaf binder, are available at the prices indicated:

The Star Guide, A Study of the Constellations, by Gilbert H. Trafton, 50 cents.

The Sky Book (includes The Star Guide) by Gilbert H. Trafton, $1.00.

Camp Fires and Camp Cookery by E. Lawrence Palmer, 25 cents.

Gall Key by E. L. Palmer, 10 cents.

Camp Cookery Hints for Leaders by Agathe Deming, 25 cents.

Moss Key by A. J. Grout, 10 cents.

A Nature Guides' Dictionary by William Gould Vinal, 10 cents.

Nature Games by William Gould Vinal, 10 cents.

Key to the Nests of the Common Summer-Resident Birds of Northeastern North America, 15 cents.

Flower Key and Check List, 10 cents.

How to Know the Ferns, 10 cents.

Modern Life Arithmetics by John Guy Fowlkes, Professor of Education, University of Wisconsin and Thomas Theodore Goff, Professor of Mathematics, State Teachers College, Whitewater, Wisconsin. Cloth. 13x20 cm. Book One, pages xiii+306. Book Two, pages xiii+317. Book Three, pages xiii+237. Book Four, pages xiii+240. Book Five, pages xiv+257. Book Six, pages xiii+262. 1929. The Macmillan Company, New York.

A Textbook in General Zoology, by Henry R. Linville, Formerly Head of the Department of Biology, Jamaica High School, New York City, Henry A. Kelly, Director of the Department of Biology and Nature Study Ethical Culture School, Fieldston, New York City and Harley J. Van Cleave, Associate Professor of Zoology, University of Illinois, Urbana, Illinois. Cloth. Pages viii+463. 13x19.5 cm. 1929. Ginn and Company, 15 Ashburton Place, Boston. Price $1.80.

Statistics for Beginners in Education by Professor Frederick Lamson Whitney, Department of Educational Research, Colorado State Teachers College, Greeley, Colorado. Cloth. Pages xvi+123. 12.5x19 cm. 1929. D. Appleton and Company, New York.

The Supervision of Secondary Subjects, edited by Willis L. Uhl, Professor Education and Dean of the School of Education in the University of Washington. Cloth. Pages xvi+673. 12.5x18.5 cm. 1929. D. Appleton and Company, New York.

Synchronized Reproduction of Sound and Scene. Paper. 44 pages. 18x25.5 cm. Reprinted from Bell Laboratories Record. November, 1928. New York City.

BOOK REVIEWS.

Ninth Grade Mathematics, by Flora M. Dunn, Head of Mathematics Department, Emmy S. Huebner, Teacher of Mathematics, both of the Fairfax High School, Los Angeles, and John S. Goldthwaite, Head of Mathematics Department, Lincoln High School, Los Angeles. Pages viii+290. 14x19.5 cm. 1929. Ginn and Company. $1.20

The authors have designed this text for the use of students entering high school with no intention of attending college. For this reason they have omitted a large part of the formal algebra usually found in text books of algebra and have replaced it by constructive geometry.

The book is divided into three parts. The first part provides work in constructive geometry for the first semester. In this course they aim to have the student become familiar with the ideas of equality and symmetry and to learn to appreciate the geometric forms found all about him.

The second part consists of algebraic material based on formulas. These formulas are grouped under many headings with many problems under each. The authors believe that after the student has mastered these problems he will be prepared to handle the mathematics required in the first two years of any shop work and will be better prepared to deal with the formulas of chemistry and physics than if he had pursued a course in ordinary algebra.

The third part consists of arithmetic material to be used for drill purposes whenever the teacher feels the pupils need such drill.

J. M. Kinney.

First Course in Algebra, by W. H. Williams, Head of the Department of Mathematics, State Teachers College, Plattville, Wisconsin, and Mona Dell Taylor, Instructor in Mathematics, West Technical High School, Cleveland, Ohio. Pages iv+379. 13x19 cm. Lyons and Carnahan, Chicago. 1929.

This is a conservative algebra for which the authors claim the following features: (1) the work is correlated with arithmetic; (2) But one difficulty is introduced at a time; (3) The equation is emphasized; (4) Stress is laid on mental work; (5) A large proportion of simple exercises is given; (6) Algebraic language is emphasized. J. M. Kinney.

College Algebra, by Bolling H. Crenshaw, Head Professor of Mathematics, and Duncan C. Harkin, Associate Professor of Mathematics, both of Alabama Polytechnic Institute. Pages xiii+224. 13.5x20 cm. P. Blakiston's Son and Company, 1012 Walnut St., Philadelphia. $1.75.

The book opens with a chapter on fundamental concepts, such as the laws of operation, number and field, variable, and algebraic function. The second chapter deals with linear equations in two and three unknowns. By making use of the notion of detached coefficients, determinants are introduced and used in solving these equations. There is a chapter on series in which the notion of finite differences is used in finding sums. The book closes with a chapter on the theory of numbers.

J. M. Kinney.

General Science Course for Seventh, Eighth and Ninth Grades by Joseph R. Lunt and Dennis C. L. Haley, The Teachers College of the City of Boston. Cloth. 21.5x27 cm. L. E. Knott Apparatus Company, Cambridge, Massachusetts. The price of each unit is 25 cents. Special price in quantity.

This is a complete course in general science arranged according to the unit plan. Each unit starts with a list of a dozen or more of sub-topics headed "What It Teaches." This is followed by a complete list of "Ma-

terials and Apparatus" with numbers from the L. E. Knott Apparatus Company's catalog for ordering replacements. Each unit consists of definite directions for the experimental solution of problems proposed by the authors. The entire course consists of thirty-one units. The publishers supply all apparatus and materials needed for each unit, arranged in a convenient carrying case or cabinet labeled with the unit name and number. G. W. W.

The Radio Manual by George E. Sterling, Radio Inspector, Radio Division, U. S. Department of Commerce Member, Institute of Radio Engineers, and Edited by Robert S. Kruse, formerly Technical Editor QST. Magazine of American Radio Relay League; Consultant for Development of Short Wave Devices, Technical Editor and Writer. Third Printing. Cloth. Pages v+666. 13.5x20 cm. 1928. D. Van Nostrand Company, Inc., 8 Warren Street, New York. Price $6.00.

"This work has been prepared to serve as a guide and text book to those who expect to enter the radio profession as an engineer, inspector, commercial or amateur operator." It includes much more than is ordinarily implied by the word manual. Both the general theory and the practice of installation, operation, control and repair of all forms of radio apparatus are discussed. All explanations are in terms of the electron theory. The authors start with the simplest electric and electro-magnetic phenomena and fully discuss the construction and theory of all apparatus used in radio work. It is thoroly up-to-date and gives complete information on broadcasting, transmitting, receiving, marine and aircraft radio beacons and direction finders. The chapter on short wave apparatus for amateur use brings the story down to the present year and gives some indication of what may be expected in the immediate future. Information needed by applicants for positions as radio operators, inspectors and engineers in commercial and federal work is given. G. W. W.

Food Products, Their Source, Chemistry, and Use by E. H. S. Bailey, Ph. D., Professor of Chemistry and Director, Chemical Laboratories, University of Kansas and Herbert S. Bailey, A. B., B. S. Formerly Chief, Div. Fats and Oils, U. S. Bureau of Chemistry. Third revised Edition. Cloth. Pages xviii+563. 13.5x20.5 cm. 1928. P. Blakiston's Son & Company, 1012 Walnut St., Philadelphia. Price $2.50.

The immediate purpose of the authors is to give their readers a practical knowledge of what constitutes good food, how it is produced, manufactured and prepared. They hope that such knowledge will result in improvement in the general food supply. The third edition, which came from the press a short time ago aims to give the developments of the last few years in the sources, manufacture, preservation and transportation of food products. The first chapter gives general information relative to the sources of foods, their constituents from a chemical standpoint, heat values, and a classification of foods. Each of the next eighteen chapters deals with a particular class of food. The last chapter gives a brief history of the pure food movement. The language is simple and generally non-technical. The index is accurate and fairly complete. The book is suitable for either home or school library and may be used as a text or reference book for classes studying foods. G. W. W.

Outdoor Adventures by Albert E. Shirling, Department of Natural Science and Geography, Teachers College, Kansas City, Missouri. Cloth. Pages vi+250. 13x18.5 cm. 1928. World Book Company, Yonkers-on-Hudson, New York. Price $1.00.

This is a very attractive little nature story book for boys and girls in the elementary grades. Roger, a boy from the city, is spending the summer on the farm with his friend Tom. The boys have great fun watching the spiders, squirrels, crawdads and dozens of other curious creatures. Each is able to tell the other interesting things about the insects, animals and birds they find. The book contains numerous illustrations, many of which are photographs of insect and animal life.

G. W. W.

Soap Bubbles by Ellen Beers McGowan, School of Household Arts, Teachers College, Columbia University. Cloth. Pages viii+248. 13.5x18.5 cm. 1929. The Macmillan Company, New York. Price 80 cents.

This is another interesting book for elementary science. It is designed to serve either as a supplementary reader or as a text book for the upper elementary grades. It relates in simple language the history of the soap making industry and tells all about the uses of many kinds of soap, and why they bleach or scour or clean. Many simple experiments are suggested that can be done either in class or at home.

G. W. W.

A Laboratory Manual of General Botany, by Emma L. Fisk and Ruth M. Addoms, Department of Botany, University of Wisconsin. Cloth. Size 14x21 cm., 103 pp. Published by The Macmillan Company. 1928.

This manual is written for the use of freshman classes in college and designed to be used with a text book of General Botany by Smith, Overton, Gilbert, Denniston, Bryan and Allen, but may be used with other texts. The lessons are arranged in two series: "Part I. Seed Plants: Their structures and functions. Part II. A survey of the plant Kingdom." There are also appendices on the selection and preparation of material used in the laboratory and various formulæ needed in the course.

The lessons are well written and particularly good for their conciseness and direct attack of the studies. A good feature is the use of a different style of type for directions for notes and for the drawings. We think this an unusually good book for college use, and also will prove useful to high school teachers of botany as a reference book. W. W.

THE ERUPTION OF KILAUEA.

By T. A. Jaggar.

Lava fountains 200 feet high along a crack on the bottom of Kilauea's most active pit were the most awesome features of the great eruption that began shortly after midnight on the morning of February 20. A crack 1300 feet long runs across the northwestern part of the bottom of Halemaumau Pit, and it is from this that the fiery fountains rushed upward.

A lava lake sixty feet deep, with diameters of 1500 and 1000 feet, has formed, and is rising at the rate of five feet per hour. After twelve hours of eruption, the fiery jets of the fountains rose 100 feet above the surface of this lake. The fountains were casting drops of lava into the air, which fell as they cooled. At first the stony shower consisted of pumice, but now the lava drops are glassy, and there are great quantities of lava needles, and of fine brown wind-spun lava threads known as "Pelé's hair." Pelé was the ancient Hawaiian goddess of the volcano.

The eruption has been accompanied by a display of bright light and a constant rumbling noise. Clouds of blue, sulphurous fumes roll into the air from the pit.

The seismograph at Volcano House shows a continuous volcanic trembling and tilts away from the pit.

Halemaumau Pit, where the present eruption is centered, is Kilauea's usual focus of activity. It is an enormous hole in the southwestern floor of the crater, 3400 by 4000 feet. Landslides of material previously piled up on its slopes are constantly sliding into its depths, and these volcanic avalanches have been going on incessantly since the present eruption started.

It is expected that the eruption will continue for some weeks at least.—*Science News-Letter.*

AIDS FOR THE TEACHING OF SCIENCE.

By J. H. Jensen,
Northern Normal and Industrial School, Aberdeen, S. D.

WALTER BAKER & CO., Ltd., Advertising Dept., Worchester, Mass. Pamphlets: Cocoa and Chocolate. Free.

BARBER ASPHALT CO., Philadelphia, Pa. Material on: Asphalt. Free. Pamphlets: "Wonderland of Trinidad." Free.

THE BARRET CO., Advertising Dept., 1017 Olive St., St. Louis, Mo. Chart: Diagram of Products Derived from Coal. Free.

THE BECKWITH CO., Dowagiac, Mich. The Vital Necessity of Humidity in Living Rooms. Free.

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THE BROWN INSTRUMENT CO., Philadelphia, Pa. Charts: Melting Point of Chemical Elements.

JOSEPH BURNETT CO., 36 India St., Boston, Mass. Pamphlets: Story of Spices. Story of Vanilla. Free.

BUSSMAN MANUFACTURING CO., Sales Dept., N. 23rd St., St. Louis, Mo. Pamphlets: Fuseology. Catalogue of Buss Products. Free.

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CHEMICAL FOUNDATION CO., New York City. Booklet: The Ultimate Mission of Chemistry. The Fifth Estate. Free. Set of 8 books on Chemistry. (Includes Creative Chemistry, Chemistry in Industry, 2 vol., Chemistry in Agriculture, The Riddle of the Rhine, Discovery, etc.) $5.00.